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MEMOIRS AND PROCEEDINGS

OF THE

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NOTE.

THE authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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PRESIDENTIAL ADDRESS.

The Preservation of Our Fauna.

By THE PRESIDENT,

T. A. COWARD, M.Sc., F.Z.S., F.E.S.

(October 4th, 1921.)

Your Society in honouring me by electing me as President has given an opportunity of disseminating some of the views which to my mind are of national importance. Nay, I go further; they are of international importance, and though I can speak best about the effect of protection in our islands, the need is as great in other countries, though the constituents of the fauna differ, and the destructive agencies may not be the same. The *Memoirs* go to all parts of the world; perhaps in other lands some may realise that, before it is too late, it is a duty to posterity to preserve and protect those creatures whose existence is so much within the power of predatory man.

The subject of this address is the Preservation of the Native Fauna, but exactly the same necessity applies to the Flora; to the botanist I leave the pleading for his branch, though indeed in many instances the two cannot be separated. The destruction of the food plant may mean the end of those creatures which feed upon it; the annihilation of one particular insect may destroy the plant that it fertilises.

Later, I shall have something to say about the alien or colonist fauna, but the remarks on the whole apply rather to the native or ancient fauna, those animals which inherited this land of their birth before we, mostly descended from alien invaders or colonists, decided that the land was ours, not theirs. It is a strange ethical question this proprietorship—and Man, thinking himself Lord of Creation, demands, like "Cunning Old Fury," the right of Life or Death over all the so-called lower animals.

*November 30th, 1921.*

"I'll try the whole cause, and condemn you to death," is the usual verdict.

Maybe, Man has the right of might, whether by strength or learning, of cultivating certain plants and animals at the expense of others, and condemning those which are in his way as "weeds" or "vermin," but he is apt to overlook a very important point. Knowledge is progressive, and, as the historian knows, the acme of knowledge is a matter of the age; what is wisdom to-day may be foolishness to-morrow. The learning of the past, in some cases at any rate, is ridiculous in our twentieth century eyes; in each era there were philosophers who believed that they had reached the top of the tree. Alas, for their folly!

Just as the scientific manufacturer, generally through the chemist, constantly finds fresh use for his bye-products, the rejectamenta of former years, so the economic zoologist finds value in the condemned weed or vermin. Furthermore, there is at the present time a growing belief in the inter-relation of all life, and though the study of ecology is in its infancy, and so far has failed to throw strong light upon the so-called balance of nature, it is on the right track. When it becomes the life work of many more philosophical naturalists, and is not merely treated as something to dabble with during years of preparation for some more lucrative career, we shall have discoveries which will make us very diffident about destroying or even attempting to destroy organisms which at the present time we think are in our way.

What is the object of protection or preservation? Why do we endeavour to maintain one plant or animal, or urge that all should have consideration? There are four main arguments brought forward in support of Protection, and though the first three are for specializing, or selecting individuals or groups of individuals for care, the last applies to creatures as a whole. The one which perhaps appeals to the largest number, and which gets most support in that agent of popular propaganda—the Press—is the Economic Argument. The lay and commercial mind understands this line of reasoning. Your animal is or may be of value—to whom or what?—to mankind in general; of value commercially; of value as a means of checking the increase of, or even of destroying, something else which appears detrimental to human welfare; of value as food for some other creature whose body or products are a commercial or agricultural (one and the same thing) asset for Man. It must therefore be protected, not for its own sake but for the welfare of another,

must indeed be exploited for that other—Man. For this reason (and, are we ashamed to say, for this reason only?) exists our Board of Agriculture and Fisheries, striving to regulate the numerical proportions of certain creatures, and to instil its doctrines into a rather slow and old-fashioned constituency.

So far so good; since man has a right to keep his end up, even though we class him as but a competing animal, he must use all his arts and sciences, the product of his superior brain, to accomplish his ends. I do not condemn him; indeed I strongly uphold, the study of economic zoology and botany, and especially advocate that sensible assistance should be given with this end in view to our schools and universities. Unless we treat such delicate matters in a truly scientific manner we shall land ourselves in a more parlous state than we are at present. It is not to the academic mind that we need to appeal, but to the great body of electors whose duty it is to send as representatives men who will realise that science is the driving power in life, and that science without education is impossible. The economic argument may not be disinterested, but it is important, very important indeed.

The second argument for protection is the *Æsthetic* one, and this, with a few exceptions, is confined to propaganda on the subject of bird preservation. Bird protectors, both in societies and Parliament, are largely backed by the economic issue, and many, who are influenced purely by *æsthetic* stimuli, make use of the economic argument; for that they know will appeal when their own desires fail to attract. The bird protector, however, is fully alive to the value of the *æsthetic* argument in certain circles, and gains much support from the sympathy and purses of ladies and others who are mainly concerned with "the poor, pretty little birds." From the purely *æsthetic* side there is much to be said in favour of maintaining all birds of bright plumage or pleasant voice, and there is, perhaps, nothing else which will combat that depraved commercial spirit which fosters the pseudo-love of the beautiful in the head-gear of unthinking woman—a survival of barbarity. When it is a question of the plumage trade use the *æsthetic* argument for all it is worth.

The third argument, which may be called for want of a more descriptive title, the *Humanitarian* argument, appeals most strongly against the cruelty of destruction. There is sound good sense in it, too, but it is often marred by a strange lack of balance. Men and women who sicken at the sight of pain in animals they admire, will ruthlessly inflict it upon



those they class as vermin or merely consider ugly. Here again, where there is cruelty in destruction, it is safe and right to use the humanitarian argument for all that it is worth, but we must avoid faddism; the massacre of the plume-bearing herons for the "ospreys" of commerce entails the slow torture and starvation of young birds as well as the cruel death of the parents, and this gruesome fact has, when pointed out by reasonable advocates, influenced many tender-hearted women to deny themselves the ornaments they coveted.

The last and least popular argument is the Scientific, or, to put it in other words, the argument for scientific reasons. It is, apart from economic arguments, most difficult to advocate, and yet, I must confess, it is the one which appeals most to my mind. It is an ethical question, and it is fair to say that its force cannot be urged without admitting an element of all other arguments. Why should it mean anything to us if a species becomes extinct, ceases to exist? Nature's competitive struggle has swept away untold forms without any call upon man's influence, swept them away before man appeared upon the earth, brushed them aside, the "thousand types," actually to allow the development of the better fitted creatures, amongst which Man ranks so high. If Man be merely looked upon as a competitor in a highly competitive world, there is no reason why we should bemoan the fate of such types as were an impediment to his development. Yet, I am sure, that this Society alone contains many who share my feeling of regret whenever they see evidence of depletion in numbers of any species; probably they also share my inability to explain why, when wanton destruction or the influence of purely natural forces is causing this reduction, a wave of sentiment, which has in it something of the feeling of chivalry, impels them to uphold the cause of the oppressed. Frankly it is not the death of the individual which matters, thus the humanitarian impulse fails to apply, it is the threatened destruction of some existing form.

We cannot argue, at any rate with ease, that we suffer personally because the great auk foolishly refused to develop wings and would persist in placing its egg on a shelving rock up which men with clubs could climb as easily as itself; is it a matter of inconvenience to us that the Greenland right-whale possessed more blubber than sense and so allowed itself to be outwitted by the northern whalers, who in their rapacity destroyed their own livelihood? Does it really matter that we never saw a living dodo, or that Wicken Fen was made a preserved area too late to save the large copper? Yet these

and many other creatures have passed but a few years, comparatively speaking, before our time, and others are passing now. We, who look at the question with what we may term scientific sympathy, mourn the loss. It is because we know that within recent years species after species has vanished, and that we know that Man's rapacity is in many cases responsible, that we are so anxious to check his evil influences whilst yet there is time.

There are two methods of stopping or at any rate retarding destruction—legislation and personal influence; each has its place, and as a rule one without the other fails. Protective laws cannot be passed without the strong use of the economic and humanitarian arguments, and the last has often failed to gain a hearing. Laws, too, are useless unless the sympathy of legislators, and the public servants whose duty it is to enforce them, is strong and constant. Our House of Commons is filled by men whose tenure of office depends too much upon topical political issues for it to spend much time upon questions that are only appreciated by the minority of voters. Thus, if we get a good sympathetic naturalist in the House, and he advocates some useful protective measure, the chances are against his success; his bill is crowded out by matters which appear more imminent but yet may have transitory importance, matters which appeal to the immediate interests, usually pecuniary, of the majority. The struggle for the Plumage Bill is a recent case in point. It was through the indifference of the majority of members who nominally supported the Bill, men of all shades of Party, that for so long it was impossible to combat the small but powerful interests of the plumage trade. Time alone will show whether in these days of economic struggle there is sufficient true sympathy with the intentions of the Bill to secure its legal enforcement.

Legislation for the protection of the fauna is not viewed with much intelligence by some of those who are sent to act as our representatives. During the second reading of the Expiring Laws Bill, in August last, one member made what he considered a witty speech, in which he poured scorn on the work of protectors. This is what he said, as quoted by Hansard:—

“Then we come to the Sand Grouse Protection Act, which inflicts penalties for killing, wounding or selling sand grouse. We are getting very near the 12th, and I suppose there are some honourable Members who know something about grouse. I believe that the object of this

Act is to acclimatise a species of bird which, when this Act was passed, was supposed to be the sand grouse but which is now recognised by ornithologists as not being a grouse at all, but a form of pigeon. The amusing part of this Act is that it was passed to protect sand grouse in this country. There has never been a sand grouse seen in this country since the Act was passed. It is called the Sand Grouse Protection Act and, apparently, like all protection Acts, it had the effect of destroying the thing which it was intended to protect. There are various forms of grouse—the red grouse, the willow grouse, and others—but the one thing that does not exist here is sand grouse, and why in the name of common sense we are going on year after year with the object of acclimatising a form of grouse which is not a grouse at all I cannot understand.”

It is perhaps unnecessary to say that every sentence uttered is erroneous; it is true that the Act, passed in 1889, was too late to save the birds which came in the 1888 invasion, but there have been seven irruptions or invasions since that date. The object, of course, was to protect a species not to acclimatise a sporting asset, as the gentleman who appeals “in the name of common sense” seemed to think. But he was not content with that; he continued by attacking the Grey Seals Protection Act of 1914, and though an Irishman, he was absolutely ignorant of his own native fauna. “Its object is to protect the species of seal known as the *Halichærnus grypus*” (this is the spelling as it appears in Hansard). “I do not know what we are protecting when it is so described. I am advised that there is no such thing in the waters of this country as the *Halichærnus grypus*. It is a variety that is found only in Scandinavia. It sometimes swims over as far as Denmark.—The humour of this legislation is that there is no such thing in this country to protect.” Comment is unnecessary.

Those who have followed since 1880 the repeated muddling alterations, amendments, and orders of the Wild Birds’ Protection Acts must realise that the passing of laws alone will accomplish nothing. The law must be backed, and backed with determination, by public opinion. Then the constable will feel that he is supported in his efforts, that the Bench is behind and not against him. It is true that many of the officers require instruction; they are not ornithologists, and may easily make mistakes about the identity of species; it is equally true that our magistrates, supposed to be educated



men, are frequently more ignorant than the constabulary. There are of course magistrates and magistrates, and we cannot expect that all should at sight be able to tell the difference between a protected and unprotected bird, but that is no excuse for doubting the word of a constable. I have in mind one local case. A bird-catcher was summoned for trapping protected redpolls, and his defence was that the birds were not redpolls but "jitties"; the constable, a Cheshire man, asserted, quite correctly, that jitty was a local name for the redpoll, but the magistrate, somewhat sharply, demanded how he knew, gave the accused the benefit of the doubt and dismissed the case. Can we expect that that officer would again expose himself to unjustifiable ridicule?

It is, as was shown, possible to ride roughshod through the existing Acts, but many constables, by bluff alone, have carried out the meaning and intention of bird protection, though they were aware that strict adherence to the letter of the law would have spelt failure. In other cases the law has been upheld by public interest and agitation; those in authority were quick enough to feel the popular pulse, though personally they cared nothing about birds.

Looking back at 50 years of struggle to legislate on behalf of wild birds we see some strange examples of the futility of human efforts, and some curious and unexpected results upon our fauna. To no man, perhaps, does bird protection owe more than to the late Professor Newton. He was a rare type of philosophical ornithologist, and largely to his determination was due the first really unselfish legislation on behalf of wild birds—the Sea Birds' Protection Act of 1869. There were earlier protective measures—indeed they date back to mediæval days, but in every other case the Acts were tainted by personal interests, and partook of the nature of game and forest laws; the bittern, heron, duck or other bird was protected in order that some privileged few might destroy it; the peregrine, hobby, and merlin were not to be exterminated, for they were required by certain noble sportsmen for hawking. Other laws were openly intended to prevent trespass; only those in high places might kill, might enjoy blood sports.

Newton, though no sentimentalist, was touched by the sufferings of the sea fowl. To the big breeding stations, especially those of Flamborough and Speeton, excursion trains were run in the nesting season from London, and, to our shame, from Manchester and other Lancashire centres; these trains were filled not with ornithologists but with "sportsmen," who shot the trusting fowl when they refused to leave their

precious eggs or young. It was butchery of the grossest kind, and the drain on numbers was beyond all calculation, for the young perished of hunger on the ledges. In many cases no effort was made to gather the spoil; gull feathers were too plentiful to make the labour profitable; the excuse of commercialism could not be given; it was sheer brutality.

"If this is not cruelty, what is it?" was Newton's indignant cry. "Can men blaze away hour after hour at these wretched inoffensive birds and call it 'Sport' without being morally the worse for it? We thank God that we are not as Spaniards are, who gloat over the brutalities of a bull-fight. Why, here in a dozen places around our own coasts we have annually an amount of agony inflicted on thousands of our fellow-creatures, to which the torture of a dozen horses and bulls in a ring are as nothing."\*

The railway companies advertised the opportunities for sport, and then the subtle trader stepped in and created a fashion in gulls' feathers; the price went up, the dealers were able to offer one shilling per kittiwake, so Cordeaux states, and one man alone boasted that he had slain 4,000 adult birds in one season. Taking into consideration the number of eggs which might have been laid and reared, the number of young which certainly must have been starved in the nest, and the wounded birds which escaped to slowly perish, it is probable that that single butcher was responsible for a reduction in one year of at least 10,000 birds. "Fair and innocent as the snowy plumes may appear in a lady's hat," says Newton, "I must tell the wearer the truth—'She bears the murderer's brand on her forehead.'"

But why agonize our feelings with things of the past? The Sea Birds' Act, though repealed, as was the later Wild-fowl Act of 1872, was, after many struggles, replaced by a better and more sweeping measure, and *all* birds are now protected. Are they? It is just because what Newton foresaw has taken place—the substitution of a nominally better Act with much wider scope, framed by men who were either indifferent or not disinterested, has failed in a great measure to preserve those species which were most in danger. It is true to say that the Act of 1869, converted into that of 1880, has saved the kittiwake, but it has not converted the sinners nor roused a better spirit in the general public. Egg-snatching on the Yorkshire cliffs is still a trade, and though under proper regulations it would not do serious damage to

\* Wollaston. "Life of Alfred Newton." 1921.

the various species which still nest there in large numbers, it has the result of delaying the nesting period and turning the young out at the end of the close season when still unable to escape the guns of the "sportsmen." I have seen in early autumn a boat load of immature kittiwakes and other gulls brought in at Flamborough; I have seen young loafers, men with money no doubt, lounging about the jetty at Knott End and shooting at every unfortunate young gull or other bird which ventured within range. "Would you stop the poor man's sport?" is a common cry; yes, and the rich man's too if he is endangering the existence of a national asset.

What happened with the Bill of 1872 is this: it was made too all-embracing to be functionable. After a British Association Close-time Committee had carefully considered all points, the Bill was framed and passed without consulting any real ornithologists. Newton, writing to his brother, says:—"Mr. Herbert, on the 21st of June last, laid a cuckoo's egg in the carefully built nest of the British Association Committee, and the produce is a useless monster—the wonder alike of the learned and the layman, and an awful warning as an example of amateur legislation."\*

In order that the sentimentalist might be propitiated such birds as robin and dunnock received protection, and a small fine, which included costs, was imposed for an offence against common birds and those which were threatened with extinction. The collector smiled, took the risk, and if caught cheerfully paid, knowing well that such fine was a minute discount off the price which he could obtain. So, in a few years the Act died, and the better framed Act of 1880 was passed, but its scheduled birds were not sufficiently protected, and in a few years so many amended clauses were added that it became necessary to describe the measure as "the Acts"; no one but the lawyer was any the wiser or better off, and few lawyers found it worth while to study the complicated problem. Until protective legislation is framed by scientific, unbiassed students of bird life, who ignore the plea of the sentimentalist and weigh with caution the enthusiasm of the economist, the depletion of bird life, that is of the species we most wish to preserve, will continue.

The law has failed to reach and check the depredations of one class of criminal (it is justifiable to use the term for any law-breaker), the greedy collector and his agents, those who supply him. The professional collector, the man who trades

\* Wollaston. *Op. cit.*



in specimens, is constantly blamed for the damage he does, for his looting is wholesale, but he would very soon turn his attention to some other method of gaining a living were he not patronized; it is the hoarding private collector, the man who pretends to be but so seldom is scientific, who is really responsible.

It must, however, be admitted, as even Newton was forced to admit, that the Acts, in spite of their blundering, have accomplished much. Public feeling was and is strong, and, backed by indifferent legislation, it has so far checked destruction that many species have benefited. Here comes an anti-climax; some of the species, actively or passively protected, have increased so enormously that they have exceeded the natural limits, overweighted the balance, and it is questionable whether further protection is or is not desirable. The æsthetic and humanitarian school are shocked at any suggestion of relaxation; the economic and scientific are in doubt, the first because personal interests are affected, the second because of the uncertainty of interference with nature's balance.

The world is a big place, but it is a very varied one; its inhabitants, whether human or otherwise, are unevenly distributed. Vast tracts are sparsely populated, others are sadly congested, but there is reason for the irregularity. The unpopulated areas are unfit, at any rate during a portion of the year, for a crowded population; the congested areas are the ones where food is obtainable. When we exclude from our thoughts colonising man, who has the power to some extent of altering the whole face of a country, we see that the lower forms must either remain in or travel to and from the best food-supplying districts or perish. Britain is a typically crowded area, and is so well stocked with various forms of life that we may treat it as a fair example of a food area. It supplies just the necessary amount of food to make life endurable for just that number of creatures which it can support; in other words, there are enough and not too many of each form existing within its bounds, and this required number depends entirely upon the seasonal supply of vegetable food, and the balanced and regular supply of animal food which depends upon the vegetation. Any shortage, due to climatic variation, of the vegetable food supply, is immediately followed by famine, which means not only famine for the phytophagous but for the carnivorous forms; a good year, an increased output of cultivation, the introduction of a new or alien crop, is followed by an increase of vegetable feeders, an increase of their natural enemies, and of the creatures which

subsist upon them. What is the result? The numbers are raised above the normal, and when the normal food supply returns, famine follows as surely as when the supply was short; there are too many mouths to be filled. Thus taking an average of years the necessary average is maintained, and this is Nature's Balance.

It is fair to say that there cannot be in any civilised, indeed in any country populated by man, a real natural balance; Man is the great disturber of Nature. But in a country like Britain, where civilisation has been working for the ends of Man for ages, there is what we may call a human or artificial natural balance; a point at which, under the present artificial system, the inter-relation of plants and animals, cultivated and domestic as well as wild, remains more or less constant. It is our duty to maintain that present day balance so far as we can consistently with our actual requirements, for if we fail mankind as well as the lower animals will suffer. It is with this end that economic zoology and botany should be studied.

The increase beyond the normal proportions of any species of bird, due to protection which has not taken into consideration consequences, may be a tragedy. It may, probably will, affect our life interests; it certainly will have influence upon the relative numbers of other forms. Need I mention as problems of the day the extraordinary increase since 1880 of the black-headed gull and the starling, two species wholly valuable in their proper proportions, but threatening other forms, actively or passively, now that they have become so numerous.

May I here mention that it was after I had thought out and actually written most of this paper that I read Dr. Ritchie's fascinating study in faunal evolution, "The Influence of Man on Animal Life in Scotland." My line of thought is practically the same as his, and, though we had arrived at the same conclusions independently, I am indebted to him for several useful suggestions. I know of no better exposition of the need for sensible and well considered protection than is supplied by this book.

Dr. Ritchie divides his subject into two parts—deliberate and indirect interference with animal life. In the first he groups domestication, intentional destruction of animals for various reasons, protection of animals for other reasons, and the introduction of new forms. In the second he deals with changes in natural environment and the influence on animals, cultivation, civilisation, and the accidental or unintentional

introduction of creatures, for the most part classed as pests. An entirely different method of grouping or analysis of results would be the dividing of those from which Man derives benefit, from those which are detrimental to his welfare. Deliberately or unintentionally man has in his dealings with animals derived profit and loss, and he has by no means invariably succeeded in attaining the ends that he desired, or which, at first blush, seemed likely to result. Animals, consciously or unconsciously, treat Man as a competing species, and however warmly a Krapotkin may advocate mutual aid, or a Drummond urge the harmony of Nature, the painful fact remains, Man and the primitive protozoon alike strives and has to strive to exist at all.

So long as the disturbance of Nature is confined to cultivation of land or domestication of useful animals, necessities for man's existence, this disturbance is not only justifiable but a duty. It may mean, it is certain to mean, destruction of many existing forms as well as individuals, but the loss cannot be helped; it is true, however, that in few cases has the cultivation for food or the destruction of animals for the same reason been the cause of extinction; it is when commercialism demands wholesale and usually wasteful methods that this undesirable end is evident. The African native, who in his pitfalls slew wholesale, for the sake of obtaining food, did less havoc than the trading sportsman who found ivory and other products meant wealth—in other words supplied more than was necessary for his welfare but not for his desired wealth. The Red Indian was not gifted with foresight in his attacks upon the bison, but he failed to destroy it until commercial Western civilisation took a hand; then the vast herds soon ceased to exist. Mr. H. J. Massingham says that "in many ways, our attitude to animals is still very barbarous and very imperfectly consistent. But it must be remembered that these barbarisms are partly vestigiary relics of an unenlightened past and partly the consequences of the detestable predatory spirit directly encouraged by commercialism."\* Not only do I endorse this, but I would add my belief that the ancient barbaric attitude, cruel, wasteful, blind though it was, was more in harmony with Nature than the greedy, commercial, Devil-take-the-hindmost spirit of the so-called intelligent man of the present day who, for his own gain, exploits the weaker brain power of less highly developed creatures. Granted, however, that a certain amount of disturbance is

\* Massingham, "Some Birds of the Country Side, 1921."



bound to follow any effort for advance, it is all the more necessary that we should take steps which will involve change only after carefully considering the cost; this cannot be estimated until we have so studied, to the best of our ability, the life history of all living creatures, that we may gain some knowledge of how far one depends upon another. Furthermore, any interference with what I have called the artificial natural balance must be watched with an open mind.

Let me illustrate this last point by a practical case. One of the questions which has constantly puzzled those who were framing laws for protection has been how far the taking of eggs of the lapwing should be prohibited; the usual conclusion is that the lapwing is wholly insectivorous, using this word in that wider sense which means invertibrate-ivorous, and that therefore it should receive the fullest protection. But two other interests are taken into consideration—the one commercial, for the eggs are in demand in the market, the other a matter of policy, the attitude towards the farmer and his hands; it is unwise to add restrictions which it is difficult to enforce. Therefore, in most cases eggs may be taken up to a certain date, but after that they are protected. But supposing that full protection is granted to the bird, and it increases, are we sure that increase is desirable? The lapwing may, when in its normal numbers, confine its attention to certain food, say the larvæ of root-eating moths, larvæ of phytophagous diptera and coleoptera, such as crane flies and wireworms, or to the small molluscs which certainly do damage. But does the bird confine its attention to these? Does it sagely examine and leave unmolested the larva of a carnivorous beetle? Can it, or indeed any bird which follows the ploughman, distinguish between the grub of a cockchafer and that of the fertilising dung beetle? And if it could have we any reason to suppose that it would leave the so-called useful insect for our benefit? And in particular, does it or does it not eat earthworms, and if it does, is it doing us good or harm? Darwin, the great earthworm's advocate, showed the utility of this despised creature, but may we not have too many earthworms? It is an unsettled problem. Leave the worm problem to the mole, some say; but do we? We destroy the mole, yet not, if we are honest, because it devours the worm but because it throws up unsightly and awkward mounds, obstacles to tillage, or, in many instances, because it has a pelt which has commercial value. But does not the worm-devouring mole do exactly what the worm accomplishes, aerate and moisten the ground through its tunnels,

and throw good top-dressing to the surface? In short we must remember that those creatures which appear to be of service by destroying pests do not discriminate; they also destroy other useful checks on these same pests. The bud-destroying bullfinch eats also the seeds of troublesome weeds, the tit kills the spider which itself ensnares alike the troublesome fly and the parasite which keeps it in check, the moth, parent of the caterpillar, and the ichneumon which destroys the grub. It is all very complicated, very confusing. All the more reason for careful, unbiassed study of all animal life; we never know where and when we may hit on fresh light, a new link in this complicated, tangled chain of nature.

Without entering into the ethics of war, we can look back and review the lessons of the recent struggle, when interference with Nature was rampant. First consider food shortage apart from political and economic causes; it was deemed necessary to encourage internal resources; we strove to increase our food supply, especially of wheat, potatoes and vegetables. We sowed wheat everywhere, but we did not always reap the harvest; in certain soils, for long unsuited to or at least unused to this crop, the wheat-bulb fly appeared and worked its wicked will. It was not, as our late member, Dr. A. D. Imms, pointed out, that *Hylemyia coarctata* was a new comer to our lands, but that wheat had been sown on unfavourable ground, following in incorrect rotation; we were, in fact, very ignorant about the life history of this fly, and unwittingly gave it an opportunity of increasing before its natural parasites had a chance of reducing its numbers to the normal. With a little more knowledge we should have avoided the catastrophe; but had we continued to grow wheat in spite of the set-back, we should probably have discovered that we had in time reached an artificial natural balance, when Man would have got some wheat, but neither would the bulb-fly nor its parasites have entirely vanished. We may, in cultivation, force the pace, we do it constantly, but ultimately natural forces assert themselves; a stable condition is reached.

Game preservation has wrought many changes in Nature's balance, and these are often closely connected with the introduction of alien creatures. A new and complex situation arose during the war; its effect is still noticeable. Apart from the previous interference with animal life caused by game preservation methods was the fact that a large number of men were engaged in continuous efforts to decrease the numbers of certain creatures, called by them "vermin," and simultaneously to increase the head of game, a persistent effort to



upset natural balance. Many of these men were drafted into the army, artificial rearing was almost entirely neglected, and much of the seasonal shooting or sport was discontinued. Immediately a change was noticeable; predatory animals such as hawks, owls, crows, magpies, jays, stoats, weasels, and foxes increased; rabbits became a nuisance in spite of controlled prices, rats were a perfect plague, and small birds decreased. Unfortunately the issue was confused by a natural catastrophe, the abnormal winter and spring of 1916-17, when so many birds suffered from starvation, and in direct consequence insect life had a chance to increase. If, however, some measure of the decrease in bird life was due to the abundance of predatory creatures, which I believe it was, we can see why the wheat bulb-fly increased, and why the forest trees for several years have suffered defoliation by the larvæ of species of *Hibernia* and *Cheimatobia*, and other insects. Possibly too it was a factor in the abnormal invasion of the upland pastures by the larvæ of the antler moth.

One remarkable, significant, and in some quarters at least unexpected result is that the stock of wild pheasants, that is to say of birds which nested and reared their young without artificial aid, is greater than before the war. It has often been asserted that the pheasant, an introduced bird, could not exist without protection; I believe that it is so firmly established as a colonist that it has reached that position when it is fitted to maintain its own natural balance. The wild birds not only could exist, but actually benefited by the absence of competition with their hand-reared brethren; there was no longer over-stocking.

Game preservation, a very ancient source of interference, has altered the constituents of the fauna more than most agencies, the cultivation of land and domestication of animals excepted; it has too often altered it for the benefit of the minority. Yet we must face the fact that the destruction of predatory creatures and the provision of shelters for game—woodlands, coverts and moors—have proved advantageous to innumerable creatures, mammals, birds and insects for example, which were innocuous to game or beneath the notice of its guardians. We have no vivid faunal picture of our land before the days of forest and game laws, but we can imagine what it was like from analogy. A friend of mine who served as a doctor during the East African campaign was much struck by the apparent absence of small birds and the visible abundance of raptorial species. He argued that there must be a wealth of bird life to feed all these carnivorous

vultures, kites, eagles, hawks and falcons, and soon arrived at the correct solution of the problem; small mammals and birds sheltered in the dense jungle, the predatory birds "waited on," as the falconer would say. When a possible victim ventured from its shelter it was at once hunted, driven back or captured. Our forests and woodlands, now reduced to a minimum, must have been similarly crowded with timorous creatures; the open country was free to the larger and more powerful forms. Man has altered all this, man with his axe and hoe has let light into the jungle. What says "The Roadmaker":—

" 'Mid vegetable king and priest  
And stripling, I (the only beast)  
Was at the beast's work, killing; hewed  
The stubborn roots across, bestrewed  
The glebe with the dislustered leaves,  
And bade the saplings fall in sheaves;  
Bursting across the tangled math  
A ruin that I called a path,  
A Golgotha that, later on,  
When rains had watered, and sun shone,  
And seeds enriched the place, should bear  
And be called garden."

When others, long before Stevenson, hacked their way through the primeval forest, "bathed in vegetable blood," they let in the predatory beasts and increased the struggle. But Man too is predatory, and from craving for food or desire for sport he helped the lesser folk at the expense of the greater, especially when he realised that these powerful creatures competed with him in blood lust. How well he succeeded in driving them from the face of the earth may be realised by the study of history. Here in Britain the white-tailed eagle and the osprey have gone, the golden eagle survives because it is useful as a protector of other game or rather as an assistant on the deer forest; the kite, once a useful and very familiar scavenger in our mediæval towns, and the harriers are reduced to a few strugglers, solely maintained by private protectors; the pine marten, badger and otter are threatened with extinction, the polecat and wild cat have within our time followed the wolf and bear. The raven once nested in our midst but now only exists in the wilds; the lesser fry have suffered too, though in a smaller degree. It was woe to many creatures when gunpowder came into general use, it was the end when the lethal weapon was "improved."

When engaged in warfare against the smaller creatures, especially those which are in reality his parasites, Man usually

fails to destroy, though he may<sup>\*</sup> succeed in keeping them in check by materially reducing numbers. But when he pits his science and cunning against the less developed intelligence of the larger forms, he can entirely wipe a species out, and often does this in his greed to secure wealth in advance of his human competitors. Thus the rat, sparrow, house fly and louse defy his efforts, and until his whole moral outlook changes, for sanitation is a moral question, his cleverest devices will fail to utterly check their ravages. Even then it is doubtful if he will ever destroy the fly and mosquito though he may render their attacks innocuous. The rat, indeed, persistently following man, has often undone his best work. Its arrival on Lord Howe Island has resulted in the ruin of that successful Australian bird-reserve.

With larger and less numerous animals the fight is more one-sided, for they are not numerous because he is numerous. How effectually he can destroy is shown by the extinction of the vast hordes of passenger pigeons, the Esquimox curlew, the great auk, and many of the Australian parrots. But we need not go beyond the limits of our own land for examples. It has often been argued that drainage of marshes or cultivation of land explain the extinction as breeding species of the bittern, ruff, black-tailed godwit, great bustard, Savi's warbler and crane. Yet the bittern, after long absence, is nesting once more in the marshes where it derives protection, private protection be it remembered, and the ruff too has returned; there are many suitable places still remaining where these birds might nest if allowed. What has happened with another marsh species, the black-headed gull? Driven from place to place by the drainage of one after another of its haunts, it has still found sites to colonise and wherein to increase. True there may be factors which explain the increase of one species and the decrease of another which have no connection with the influence, at any rate direct, of Man; we can for instance explain the increase and spread of the great crested grebe, at one time nearly swept away by the demand for its soft breast plumage—protection gave it the start it needed. But it is hard to imagine that the same factor operated in the case of the turtle dove. A change of habit and of breeding range may have influenced the godwit and black tern. It is, however, certain that immediately these and other species were seen to be rare their commercial value rose and they were hunted out of the country by the collector. When Seeböhm pointed out that the St. Kilda wren differed from the mainland form it was an evil day for the little islander; one



prominent bird protector, now no more, did his utmost to help in extinction of this subspecies.

The Rev. F. C. R. Jourdain recently called attention in the *Times* to the havoc of commercialism amongst the eiders of Spitzbergen. The motor on the sailing sloop is the engine of destruction, for it enables the egg and down-hunters to enter bays and inlets which were unsafe before its introduction. One sloop, at the end of last June, had on board "no fewer than 15,000 eggs." The remnant of the Spitzbergen eiders may be saved when there are so few that it no longer pays to exploit them, but, unfortunately, even this has not saved every persecuted species.

One of the worst destructive features is the intentional introduction of animals to a land to which they are alien. This is usually due to sentiment, but often to a desire, apparently harmless, of improving the fauna by the addition of attractive animals. The result of this well-meaning but mistaken policy is never satisfactory, at any rate for many, very many years. There is no middle course. The introduced creature either finds life so hard in the new land, and enemies so numerous that it dies out at once, or it finds conditions so favourable and natural checks so few that it increases rapidly and some less fitted native succumbs to give it room. Many efforts have been made to improve and increase the variety of our game stock, but whereas the barbary partridge, the willow grouse, the colin, bob-white, button quail, and even tinamou have been tried and failed, the red-legged partridge has established itself, and the various pheasants have settled down. Amongst mammals the reindeer, wapiti, and beaver rank amongst the failures, the rabbit is perhaps the best instance of a successful colonist; so far has it established itself that we now count it as native, and realise that it has reached that stage when an artificial natural balance with other forms is stable. But can we not guess that awful dislocation of the balance amongst native forms occurred before the rabbit found its level; how many creatures whose absence we mourn may have owed their decline to competition with the rabbit? What it can do when placed in an alien land we know, for is not Australia still faced with the problem, and have not other efforts to check it by introducing its foes—stoat, weasel, dog, cat, and fox—all had bad results, the destruction of the native fauna or the colonists' stock, but not of the prolific alien.

Later enthusiasts have brought us the little owl and grey squirrel, and we have yet to see the full results of the folly of

introducing successful colonists. At Woburn already it has been necessary to have a squirrel drive, and though neither squirrel nor little owl may be guilty of all the crimes laid to their charge, it is certain that as both are rapidly spreading some other creatures are suffering. I have heard complaints from Hertfordshire and Northants, where the little owl flourishes, that the tawny and barn owl are decreasing; there is only a certain catchable quantity of owl food and the smart little owl is getting the pick. The bird has now reached our area, where during the last ten years or so the barn and tawny owls have increased; what will the next decade show?

There are many introductions for which we are not intentionally responsible, creatures which travel with and in our food supplies. Many of these come merely as stowaways and perish in an inhospitable land, but others, the hangers-on of civilisation, follow man wherever he takes or sends his supplies. The codlin moth, estimated to cost America at least £2,000,000 annually, we sent from Europe, and in return we have to thank America for the American blight. Cockroaches travel from various parts of the world, for they are great navigators, and colonise wherever they land. The Mediterranean flower moth is everywhere, its land of origin is uncertain, and that small weevil, *Calandra granaria*, is a similar cosmopolitan pest. These and many others, too numerous to mention, increase and spread as trade increases and spreads. We must investigate their life story and take whatever course we can to reduce them to their original status.

Having realised that Man not only has been but still is responsible for great changes in animal life, many of which entail the passing of species, two questions may with reason be asked. Why should we endeavour to preserve any of those animals which are so feeble that they cannot keep their own ends up? To that I would answer with other questions. Do we desire to see any of the existing forms follow after those which have gone? And do we look forward with joy to a land, nay a world, peopled only by Man, his domesticated slaves, his animate commercial assets and his parasites? If this is not a pleasant outlook, then what must we do?

There are, as I have said, two ways of dealing with Protection—legislation and public opinion. If we foster the latter the former will follow. But we want our legislation to be wise, and to achieve this our advocacy of the cause must also be wise. Newton, as bird protector, was sarcastic about many methods of its advocates. "The worst is that people will gush and be sentimental . . . the sentimentalists give far

more trouble than anyone else." He was also down on the extravagant assertions, over-coloured statements of letter writers:—"Our wild animals have no great reason to be grateful to their ordinary defenders in the newspapers." It is true. We need moderate, cool statement of fact, based on the study of life in field and laboratory, and the philosophical application, after careful experiment, of what we have learnt. Above all let us so order our behaviour towards the lower animals that it may not be asserted by the generations to come that the thoughtless, selfish men of the present era destroyed or allowed to be destroyed, for their own commercial ends or for their sporting pleasure, creatures which belonged to all time, the Men of the future as well as the Men of to-day.

In conclusion. Do these creatures *belong* either to us or to those who will follow? Have they not equal rights to a place in the sun? If so, we are justified only in destroying when and where we are forced to maintain our own competitive position.

## I. On Certain Integrals Occurring in the Kinetic Theory of Gases.

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(1) Among the more important molecular models used in the kinetic theory of gases are point centres of force varying as the inverse  $n$ -th power of the distance. The expressions for the coefficients of viscosity, diffusion, and thermal conduction for a gas composed of such molecules contain as factors certain numbers defined in the form of definite integrals. These integrals have been calculated by quadratures in one case, treated of by Maxwell, *i.e.*, the case  $n=5$ .<sup>1</sup> Lord Rayleigh<sup>2</sup> showed how the value of  $n$  may be deduced from the temperature-variation of the coefficient of viscosity of a gas, and in general it is thus found that  $n$  is greater than 5. In order, therefore, to calculate the intensity of the fields of repulsive force surrounding such molecules, from the observed coefficients of viscosity and diffusion, it is necessary to determine the said integrals for values of  $n$  greater than 5. The object of this note is to describe a method which has been used for this purpose, and to place on record the results so obtained.

(2) The integrals in question are defined as follows:—

$$(2.1) \quad I_1(n) = 4\pi \int_0^\infty \cos^2\theta \cdot a \, da,$$

$$(2.2) \quad I_2(n) = 4\pi \int_0^\infty \sin^2\theta \cos^2\theta \cdot a \, da,$$

where  $\theta$  is a function of  $a$  given by the equation

$$(2.3) \quad \theta \equiv \int_0^{\eta_0} \left\{ 1 - \eta^2 - \frac{2}{n-1} \left( \frac{\eta}{a} \right)^{n-1} \right\} d\eta.$$

1. MAXWELL, "Collected Papers," ii, p. 42.

2. RAYLEIGH, "Collected Papers."

In this expression the upper limit  $\eta_0$  is the (unique) positive real root of the equation

$$(2.4) \quad 1 - \eta^2 - \frac{2}{n-1} \left( \frac{\eta}{a} \right)^{n-1} = 0$$

When  $n=5$  the expression (2.3) for  $\theta$  is an elliptic function, and its numerical value as a function of  $a$  can be obtained from tables of elliptic functions. Using these values for substitution in (2.1) and (2.3), Maxwell numerically integrated the latter, and obtained the results

$$(2.5) \quad I_1(5) = 2.6595, \quad I_2(5) = 1.3682.$$

Another value of  $n$  which gives easily calculable results is  $n=2$ ; in this case it is readily found that

$$\cos^2 \theta = \frac{1}{1+a^2}$$

$$I_1(2) = 2\pi \log_e (1+a_0^2), \quad I_2(2) = 2\pi \left\{ \log_e (1+a_0^2) + (1+a_0^2)^{-1} \right\}.$$

where  $a_0$  is the upper limit in the integrals  $I_1$  and  $I_2$ ; physically regarded this limit cannot now be taken infinite, since then  $I_1$  and  $I_2$  would also become infinite. The value of  $a_0$  to be adopted depends on the maximum distance apart of the lines of relative motion of two molecules during a binary encounter. The case  $n=2$  is of physical interest only in relation to the extreme conditions found in the interior of stars, when the gas-particles are highly ionised.

Another partly integrable case is that of  $n=3$ , for which it is easily seen from (2.3) that

$$\theta = \frac{1}{2} \pi a / \sqrt{a^2 + 1}.$$

It is convenient to change the variable in (2.1) and (2.2) to  $\theta$ , using the equations

$$a^2 = \theta^2 / \left\{ \left( \frac{1}{2} \pi \right)^2 - \theta^2 \right\},$$

$$a \, da = \frac{1}{2} \, d a^2 = \left( \frac{1}{2} \pi \right)^2 \left\{ \left( \frac{1}{2} \pi \right)^2 - \theta^2 \right\}^{-2} \theta \, d \theta,$$

the limits of  $\theta$  being 0 and  $\frac{1}{2} \pi$ . The integrals (2.1) and (2.2) are readily obtainable by numerical quadrature after this substitution, the integrand being finite within the range of integration and at  $\theta=0$ , and having a finite limit at  $\theta=\frac{1}{2}\pi$ . The values obtained, dividing the range of integration into 20 equal intervals, and applying Weddle's rule for 11 ordinates (repeated), are as follows:

$$I_1(3) = 5.099. \quad I_2(3) = 3.823.$$

For ordinary gases the values of  $n$  which are of interest range from 5 to about 15.

(3) To determine  $I_1$  and  $I_2$  for general values of  $n$ , it is



necessary first to calculate  $\theta$  by quadrature of the integral (2.3), and subsequently to perform a second quadrature of the integrals (2.1), (2.2), using the computed values of  $\theta$ . None of these three integrals, however, is in a form suitable for numerical calculation, since in (2.3) the integrand is finite at the upper limit, while in the other two the range is infinite. It is therefore convenient to transform the variables so that these infinities shall disappear, leaving the integrals in a form to which Simpson's or Weddle's rule can be applied.

In the case of (2.3) it is desirable to take  $\eta_0$  rather than  $a$  as known, since it is difficult to calculate  $\eta_0$  from  $a$ , but easy to find  $a$  when  $\eta_0$  is given. Thus, if  $\eta_0$  satisfies (2.4), we have

$$(3.1) \quad a^2 = \eta_0^2 \left[ \frac{2}{(n-1)(1-\eta_0^2)} \right]^{\frac{2}{n-1}}$$

while

$$(3.2) \quad 1 - \eta^2 - \frac{2}{n-1} \left( \frac{\eta}{a} \right)^{n-1} = 1 - \eta^2 - \frac{2}{n-1} \left( \frac{\eta_0}{a} \right)^{n-1} \left( \frac{\eta}{\eta_0} \right)^{n-1} \\ = (1 - \eta^2) - (1 - \eta_0^2) \left( \frac{\eta}{\eta_0} \right)^{n-1}$$

Now introduce new variables  $\chi, \chi_0$ , defined as follows:

$$(3.3) \quad \eta = \sin \chi \quad \eta_0 = \sin \chi_0,$$

$\chi_0$  being a function of  $a$  according to the relation (cf. 3.1)

$$(3.4) \quad a^2 = \sin^2 \chi_0 \left[ \frac{2}{(n-1) \cos^2 \chi_0} \right]^{\frac{2}{n-1}}$$

while

$$(3.5) \quad 1 - \eta^2 - \frac{2}{n-1} \left( \frac{\eta}{a} \right)^{n-1} = \cos^2 \chi - (\sin \chi / \sin \chi_0)^{n-1} \cos^2 \chi_0.$$

Expressed in terms of  $\chi$ , (2.3) becomes

$$(3.6) \quad \theta = \int_0^{\chi_0} \left\{ 1 - (\sin \chi / \sin \chi_0)^{n-1} (\cos \chi_0 / \cos \chi)^2 \right\}^{-\frac{1}{2}} d\chi$$

the limits being 0 and  $\chi_0$ . Finally we transform to the variable  $z$ , where

$$(3.7) \quad z^2 = 1 - \lambda, \quad \chi = \lambda \chi_0,$$

so that  $z$  ranges from 0 to 1 as  $\lambda$  varies from 1 to 0. The expression for  $\theta$  then becomes

$$(3.8) \quad \theta = 2\chi_0 \int_0^1 \left\{ \frac{1 - (\sin \lambda \chi_0 / \sin \chi_0)^{n-1} (\cos \chi_0 / \cos \lambda \chi_0)^2}{1 - \lambda} \right\}^{-\frac{1}{2}} dz \\ \equiv 2\chi_0 \int_0^1 \phi dz \equiv 2k\chi_0$$

where  $\varphi$  represents the integrand as defined by the radical expression in brackets  $\{ \quad \}^{-\frac{1}{2}}$ , and  $k$  denotes  $\int_0^1 \varphi dz$ , which is a function of  $\chi_0$  and  $n$ .

The integral for  $\theta$  is now in a form suitable for numerical computation, because  $\varphi$  is finite throughout the range of integration, and has a finite limit as  $z \rightarrow 0$  or  $\lambda \rightarrow 1$ . This limit is readily found to be given by

$$(3.9) \text{ Lt } \varphi = \chi_0 \left\{ (n-1) \cot \chi_0 + 2 \tan \chi_0 \right\} = \frac{(n-3)\chi_0}{\sin 2\chi_0} \left\{ \frac{n+1}{n-3} + \cos 2\chi_0 \right\} \\ z \rightarrow 0$$

the second form being the more suitable for use in computation.

This gives the integrand of (3.8) when  $z=0$ . When  $z=1$ , or  $\lambda=0$ , evidently  $\varphi=1$ . For intermediate values of  $z$  the value of  $\varphi$  must be found by direct calculation (cf. §5). In this way, by applying Simpson's or Weddle's rule,  $\theta$  can be found as a numerical multiple of  $\chi_0$ , the factor itself depending on  $\chi_0$ .

(4) In the integrals  $I_1$  and  $I_2$  it is convenient to change the variable from  $a$  to  $\chi_0$ , which is defined as a function of  $a$  by (3.4). This renders the range of the transformed integral finite, since as  $a$  varies from 0 to  $\infty$ ,  $\chi_0$  ranges from 0 to  $\frac{1}{2}\pi$ . Also

$$(4.1) a da = \frac{1}{2} d a^2 = \frac{1}{2} \frac{n-3}{n-1} \left( \frac{2}{n-1} \right)^{\frac{2}{n-1}} \frac{\tan \chi_0}{(\cos \chi_0)^{\frac{4}{n-1}}} \left( \frac{n+1}{n-3} + \cos 2\chi_0 \right) d\chi_0$$

so that

$$(4.2) I_1(n) = f(n) \int_0^{\frac{1}{2}\pi} \cos^2 2k\chi_0 \frac{\tan \chi_0}{(\cos \chi_0)^{\frac{4}{n-1}}} \left( \frac{n+1}{n-3} + \cos 2\chi_0 \right) d\chi_0$$

and

$$(4.3) I_2(n) = f(n) \int_0^{\frac{1}{2}\pi} \sin^2 2k\chi_0 \cos^2 2k\chi_0 \frac{\tan \chi_0}{(\cos \chi_0)^{\frac{4}{n-1}}} \left( \frac{n+1}{n-3} + \cos 2\chi_0 \right) d\chi_0$$

where

$$(4.4) f(n) = 2\pi \frac{n-3}{n-1} \left( \frac{2}{n-1} \right)^{\frac{2}{n-1}}$$

The integrand in (4.2), (4.3), vanishes when  $\chi_0=0$ . When  $\chi_0=\frac{1}{2}\pi$ , in the denominator (allowing for the factor  $\tan \chi_0$ ) there is  $(\cos \chi_0)^{\frac{(n+3)}{(n-1)}}$ , while in the numerator the vanishing factor is  $\cos^2 2k\chi_0$ , in which  $k$  tends to 1 as  $\chi_0$  tends to  $\frac{1}{2}\pi$ ; hence

as  $\chi_0 \rightarrow \frac{1}{2}\pi$  the integrand tends to zero when  $n \geq 5$ , and this is true also when  $n=5$ , though for a more subtle reason, *i.e.*, on account of the way in which  $k$  tends to 1. Thus, when  $n \geq 5$  the integrand is zero at both ends of the range.

(5) As regards the actual work of computation, in applying Simpson's or Weddle's rule the integration in the transformed integrals, for  $I_1$  and  $I_2$  as well as for  $\theta$ , was divided into ten equal parts. Thus the integrand in (4.1) and (4.2) was calculated for the nine values  $9^\circ, 18^\circ, 27^\circ, \dots, 81^\circ$  of  $\chi_0$ , the end values (for  $0^\circ$  and  $90^\circ$ ) being zero, as just explained. This rendered it necessary to calculate  $\theta$  for each of these values of  $\chi_0$ ; in so doing,  $\varphi$  was computed for the ten values 0, 0.1, 0.2, . . . , 0.9 of  $z$ . All this was done for five different values of  $n$ , viz., 5, 7, 9, 11, and 15, it being convenient to choose odd values.

For each of these values of  $n$  and  $\chi_0$ , the limiting value of  $\varphi$  for  $z=0$  was calculated by means of (3.9); the logarithm of the last factor in (3.9), used in this calculation, was also tabulated separately, as it occurs again in the integrands of (4.2) and (4.3).

In computing  $\varphi$  for other values of  $z$ , the expression used was (*cf.* 3.8, 3.7),

$$(5.1) \quad \varphi = z \left\{ 1 - (\sin \lambda \chi_0 / \sin \chi_0)^{n-1} (\cos \chi_0 / \cos \lambda \chi_0)^2 \right\}^{-\frac{1}{2}} \\ \equiv z (1 - \cos^2 \mu)^{-\frac{1}{2}} = z / \sin \mu,$$

where

$$(5.2) \quad \cos \mu \equiv \left\{ (\sin \lambda \chi_0 / \sin \chi_0)^{n-1} (\cos \chi_0 / \cos \lambda \chi_0)^2 \right\}^{\frac{1}{2}}$$

These formulæ are suited to logarithmic calculation; thus

$$(5.3) \quad \log. \cos \mu = \frac{n-1}{2} (\log. \sin \lambda \chi_0 - \log. \sin \chi_0) \\ + (\log. \cos \chi_0 - \log. \cos \lambda \chi_0),$$

which is the more readily calculable since  $\frac{1}{2}(n-1)$  is a small whole number; a single reference to a table of logarithms of trigonometric functions then suffices to give  $\mu$  and  $\log. \sin \mu$ , for use in the formula

$$(5.4) \quad \log. \varphi = \log. z - \log. \sin \mu.$$

Seven figure tables were used in these computations, but in order to obtain  $\log. \varphi$  correct to five significant figures (as desired), only five figures were read out, except in dealing with the smaller values of  $z$ , *i.e.*, 0.1, 0.2, and 0.3.

The graph of the function  $\varphi$  with respect to  $z$  was a smooth curve to which it seemed legitimate to apply Simpson's or Weddle's rule for numerical quadrature; as an example, the computed values of  $\varphi$  are given in the following table (to three

figures only) for the extreme values of  $n$  (5, 15) and of  $\chi_0$  ( $9^\circ$ ,  $81^\circ$ ).

	$z =$	0.0	0.1	0.2	0.3	
$n = 5$	$\chi_0 = 9^\circ$	0.499	0.503	0.514	0.534	
5	81	.231	.246	.289	.353	
15	9	.268	.277	.304	.351	
15	81	.218	.233	.275	.337	
0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.564	0.604	0.657	0.725	0.807	0.901	1.0
.430	.516	.608	.703	.801	.900	1.0
.419	.505	.601	.700	.800	.900	1.0
.415	.505	.601	.700	.800	.900	1.0

The values obtained for  $\int_0^1 \varphi dz$ , or  $k$ , were as follows :

$n =$	5	7	9	11	15
$\chi_0 = 9^\circ$	1.31001	1.21432	1.16388	1.13269	1.09614
18	1.30676	1.21418	1.16468	1.13382	1.09737
27	1.30066	1.21354	1.16579	1.13558	1.09943
36	1.29054	1.21163	1.16677	1.13772	1.10227
45	1.27460	1.20705	1.16666	1.13966	1.10566
54	1.25022	1.19734	1.16358	1.13996	1.10889
63	1.21394	1.17833	1.15371	1.13543	1.10985
72	1.16187	1.14374	1.13008	1.11920	1.10266
81	1.09081	1.08599	1.08208	1.07877	1.07326

The value of  $k$  for  $\chi_0 = \frac{1}{2}\pi$  is unity for all these values of  $n$ .

The corresponding values of the integrands of (4.2), (4.3) were next calculated, the expressions for them being suitable for logarithmic computation. As examples of the way in which the integrand varies between the limits of  $\chi_0$ , i.e., 0 and  $\frac{1}{2}\pi$ , the following values are given (here to three decimal places only) for the two extreme values of  $n$  :

Integrands of  $I_1$  and  $I_2$  (cf. 4.2 and 4.3).

$\chi_0 =$	$0^\circ$	$9^\circ$	$18^\circ$	$27^\circ$	$36^\circ$
$I_1(5) =$	0	0.607	1.094	1.373	1.410
$I_1(15)$	0	0.352	0.625	0.764	0.751
$I_2(5)$	0	0.025	0.174	0.454	0.741
$I_2(15)$	0	0.010	0.071	0.187	0.306
	$45^\circ$	$54^\circ$	$63^\circ$	$72^\circ$	$81^\circ$
	1.234	0.922	0.570	0.267	0.068
	0.614	0.413	0.216	0.076	0.012
	0.875	0.787	0.539	0.263	0.068
	0.358	0.309	0.191	0.074	0.012

After evaluating these various integrals by Simpson's rule (the integrand being calculated to five decimal places in each case), they were multiplied by the appropriate values of  $f(n)$ , giving as the final results the following values for  $I_1$  and  $I_2$ :

$n =$	5	7	9	11	16	$\infty$
$I_1 =$	2.6514	2.4219	2.4000	2.4093	2.4698	3.1416
$I_2 =$	1.3700	1.1203	1.0435	1.0008	0.9723	1.0472

The values in the last column were arrived at as follows: from (3.8) it is evident that as  $n \rightarrow \infty$ ,  $k \rightarrow \frac{1}{2}$ , i.e.,  $\theta = \chi_0$ . Similarly (4.2) and (4.3) reduce to

$$I_1(\infty) = f(\infty) \int_0^{\frac{1}{2}\pi} 2 \sin \chi_0 \cos^3 \chi_0 d\chi_0 = \frac{1}{2} f(\infty),$$

$$I_2(\infty) = f(\infty) \int_0^{\frac{1}{2}\pi} 2 \sin^3 \chi_0 \cos^3 \chi_0 d\chi_0 = \frac{1}{6} f(\infty),$$

while  $f(\infty) = 2\pi$ .

Hence  $I_1(\infty) = \pi$ ,  $I_2(\infty) = \frac{1}{3}\pi$ .

This case corresponds physically to rigid elastic spherical molecules.

It is satisfactory to find that for  $n=5$  the above values of  $I_1$  and  $I_2$  are in good agreement with those found by Maxwell, by a different method of quadrature. The above are respectively 0.3% less and 0.4% greater than Maxwell's values for  $I_1(5)$  and  $I_2(5)$ .\*

The above values enable curves to be drawn representing  $I_1(n)$  and  $I_2(n)$ —preferably with  $1/n$  as abscissæ (ranging from 0 to 0.2)—with sufficient accuracy for purposes of interpolation between  $n=5$  and  $n=15$ .

## APPENDIX.

If the force between two molecules, of molecular or atomic weight  $N$  (oxygen being 16), is  $\mu/r^n$  at distance  $r$  apart, the expression for the viscosity of a gas is†

$$(A.1) \quad K = A (N m_0 R T)^{\frac{1}{2}} \left\{ \frac{R T (n-1)}{\mu} \right\}^{\frac{1}{2}(n-1)},$$

where  $m_0$  is the mass of a molecule or atom for which  $N=1$ ,

\* Since this paper was written I find from a reference by Dr. D. Enskog in *Arkiv för Matematik, Astronomi och Fysik*, Bd. 16, No. 16, p. 36, 1921, that Aichi and Tanakadate have also re-calculated  $I_1(5)$  and  $I_2(5)$ . Their values are 2.6512 and 1.3704 respectively, agreeing much more closely with those here given than with Maxwell's values. NOTE ADDED FEB. 3, 1922.

† S. CHAPMAN, *Phil. Trans.*, 1915, A, 216, 279; ENKOG, Inaugural Dissertation, Upsala, 1917; JEANS' "Dynamical Theory of Gases," p. 287, 3rd ed., 1921.



T is the absolute temperature, and R is the gas constant, while A is a numerical quantity given by

$$(A.2) \quad A = \left\{ 5 \pi^{\frac{1}{2}} \Sigma \gamma_r \right\} / 8 I_2(n) \Gamma\left(4 - \frac{2}{n-1}\right).$$

The sum  $\Sigma \gamma_r$  is a number nearly equal to 1, and depending only on the value of  $n$ , and on this only to a slight degree.

Thus the dependence of the viscosity on the temperature is according to the law

$$(A.3) \quad K \propto T^s,$$

where

$$(A.4) \quad s = \frac{1}{2} + \frac{2}{n-1}.$$

Thus  $n$  may be inferred by observing the variation of  $K$  with respect to temperature.

The distance ( $r_0$ ) of closest approach between two molecules moving towards one another in a direct line, each with the mean molecular energy  $\frac{3}{2}RT$ , is given by

$$(A.5) \quad r_0 = \left[ \frac{\mu}{3(n-1)RT} \right]^{1/(n-1)}$$

Expressed in terms of  $K$  and  $N$ , by means of (A.1), this becomes

$$(A.6) \quad r_0 = 3^{-1/(n-1)} A^{\frac{1}{2}} (m_0 RT)^{\frac{1}{2}} (N^{\frac{1}{2}}/K)^{\frac{1}{2}} \equiv A_T (N^{\frac{1}{2}}/K)^{\frac{1}{2}}$$

The force  $F_0$  at this distance is given by

$$(A.7) \quad F_0 = \mu/r^n = 3(n-1)RT/r_0 \equiv A_T^1 (K/N^{\frac{1}{2}})^{\frac{1}{2}}$$

where

$$(A.8) \quad A_T^1 = 3(n-1)RT/A_T$$

the force  $F$  at any other distance  $r$  is  $F_0(r_0/r)^n$ .

It is convenient to tabulate  $\log. A_T$ ,  $\log. A_T^1$ , for the temperature  $0^\circ\text{C.}$  or  $273^\circ\text{ absolute}$ , using the values of  $I_2(n)$  calculated in this paper: the value of  $\Sigma \gamma_r$  has been estimated for the various values of  $n$  as follows,

$n =$	3	5	7	9	11	15
$\Sigma \gamma_r =$	1.01737	1.00000	1.00170	1.00400	1.00625	1.00815

while

$$m_0 = 1.651 \cdot 10^{-24} \text{ gm.}, \quad R = 1.372 \cdot 10^{-16}.$$

The results are

$n =$	3	5	7	9	11	15
$\log. A_T =$	11.7068	10.2719	10.3146	10.3292	10.3378	10.3431
$\log. A_T^1 =$	3.6450	3.3809	3.5144	2.6247	2.7130	2.8533

## II. Number-Forms.

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An excellent illustration—and, to those unfamiliar with it, an amazing one—of the manifold ways in which meaning may be carried by mental imagery is afforded by the number-form, one of the perennial delights of the beginner in psychology. The characteristics of this type of mental apparatus were first described by Galton (3, 79—105). Since his time, however, comparatively few treatments of the subject are to be found in psychological literature.<sup>1</sup>

To those readers who do not possess this mental gift, Galton's original description may be recommended. He mentions that persons who are able to visualize a number sometimes see it not only in some particular direction with regard to themselves, but also at some definite distance.

“ If they were looking at a ship on the horizon at the moment that the figure 6 happened to present itself to their minds, they could say whether the image lay to the left or right of the ship, and whether it was above or below the line of the horizon ; they could always point to a definite spot in space, and say with more or less precision that that was the direction in which the image of the figure they were thinking of first appeared.

“ Now the strange psychological fact to which I desire to draw attention is that among persons who visualize figures clearly there are many who notice that the image of the same figure invariably makes its first appearance in the same direction and at the same distance. Such a person would always see the same figure when it first appeared to him at (we may suppose) one point of the compass

1. Professor M. W. Calkins's (1) article on the subject contains much valuable information. Professor G. E. Müller's (4) gives a lengthy general account of this phenomenon, with reference to the work of others. The three works 1, 3 and 4, together with the results of examining a series of number-forms kindly contributed by the author's friends, form the chief basis of this chapter.

to the left of the line between his eye and the ship, at the level of the horizon, and at twenty feet distance. Again, we may suppose that he would see the figure 7 invariably half a point to the left of the ship, at an altitude equal to the sun's diameter above the horizon, and at thirty feet distance; similarly for all the other figures. Consequently, when he thinks of the series of numerals 1, 2, 3, 4, etc., they show themselves in a definite pattern that always occupies an identical position in his field of view with respect to the direction in which he is looking.

"The pattern or 'Form' in which the numerals are seen is by no means the same in different persons, but assumes the most grotesque variety of shapes, which run in all sorts of angles, bends, curves and zigzags, as represented in the various illustrations to this chapter. The drawings, however, fail in giving the idea of their apparent size to those who see them; they usually occupy a wider range than the mental eye can take in at a glance, and compel it to wander. Sometimes they are nearly panoramic."

To the person who possesses no vestige of a number-form such a description may seem far-fetched. He is, however, likely to discover on investigation that it has been fetched from no farther than next door. Yet many people who possess no number-form indubitably show the undeveloped foundations of one; for number-forms are by no means rare. Of 525 persons who were questioned 35, or 6.7%, were found to possess them. Moreover, the answers of many people who possess no number-form imply that the undeveloped foundations of one are present in their mind. Phillips (4), for example, found that of 250 adults, who believed that they possessed no number-form, not less than 210 had a feeling that numbers in some way recede from them. Many reported that they have an upward movement. For others they appeared to go straight in front or at an angle of 45 degrees.

It is the striking absence of such vagueness, however, which usually characterises the description of a number-form by its possessor. He will readily assent to a suggestion that he should make a tri-dimensional wire model of it. The quick look of intelligence with which he answers your questions;—as if, writes Galton, some chord had been struck which had not been struck before;—and the rapidity and preciseness of his replies impress one only a little less than the frequent confession that up to that moment he had supposed everyone else to possess his gift.



The reader will find in Galton's book descriptions of many number-forms. To them may be added the following account of a form which, while it illustrates many usual characteristics, is of interest in that in certain other important respects it cannot be called typical. It is that of Professor W. M. Tattersall, of Cardiff, to whom, as well as to other friends mentioned below, I express my thanks for their kindness in readily supplying me with these details.

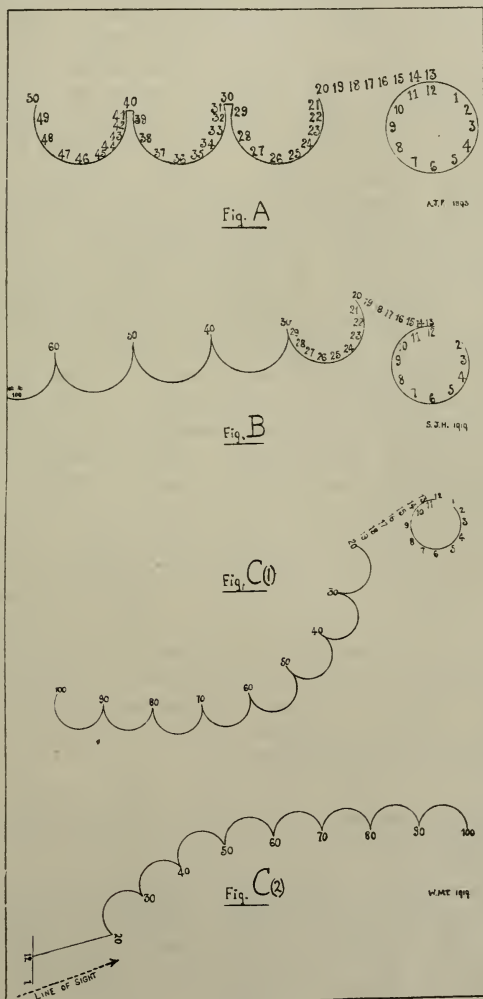


Fig. 1.

"The essential parts of my number-form are shown in *Fig. C (1)*. There is an incomplete circle, round which the numbers 1 to 12 are placed equidistantly. This is simply a clock face, but there is always a gap between 12 and 1, not filled in. The numbers from 12 to 20 are arranged in a straight line sloping down from 12 and away from it. The numbers from 20 to 100 are arranged in a series of semi-circles<sup>1</sup> of 10, round a semi-circle, so that 100 is on the same level as 20. But the number-form is not all on one plane, and in *Fig. C (2)* I have attempted to show exactly how it appears to me. The whole scheme is visible at once, and I appear to be looking down on it from above, along a line of sight indicated by the arrowed and dotted line. Thus 20 is lower down than 12, and 36 is the lowest of all the numbers. The numbers 36 to 100 are increasingly higher up, the number 100 being on the same level as 20, but much farther away. The plane of the semi-circle on which the semi-circles of numbers from 20 to 100 lie is inclined at an angle to the plane of the numbers 12 to 20, so that the number 36, besides being the lowest of the numbers is also the farthest away to the left.

"When thinking of any number from 1 to 100, I immediately visualize it in its place in this scheme. For numbers higher than 100 the visualization varies according to the character of the number. For instance, 400 has the same position as 4, 900 as 9, 1200 as 12, 1700 as 17, 2000 as 20, and so on. But for numbers like 425 there is a general tendency to split the number-form into two parts, first visualizing 4, then 25. For numbers sufficiently near to 100, say 337, I visualize at once three complete schemes and the position of 37 in the fourth scheme. But as the numbers get higher, as, for instance, 876, I visualize 8 and a diminutive scheme between 8 and 9 in which the position of 76 is visualized. In the higher numbers, such as 4678, the splitting of the visualization is always complete; I visualize the position of 46 and 78.<sup>2</sup>

1. An important emendation of the word semi-circle, added subsequently by Prof. Tattersall, appears on p. 5. I have thought it best to give the original term here.

2. (Added subsequently.) "The relative scale in which one is thinking often determines the position of a number in the number-form. For instance, it is usual to think of salaries in terms of *hundreds* of pounds, and so in visualizing the 2000 in a salary of that dimension it becomes 20 hundreds and has the position of 20. On the other hand, populations of places are usually thought of in terms of *thousands*, and the 2000 in such a case would have the position of 2."

“ When adding or subtracting numbers like 460 and 780 the positions of 46 and 78 are the dominant ones. But if the numbers were 468 and 784, then the positions of 68 and 84 would be the dominant ones. 10,000 has the same position as 10, 20,000 as 20, and so on up to 100,000, which has the same position as 100.<sup>1</sup>

“ Sums of money are visualized according to their size. Sums between 1 penny and £1 are usually visualized in pence, but if even shillings then they are visualized according to the number of shillings. Thus 15/- visualizes as 15, but 15/6 as 186. Sums between £1 and £5 are invariably visualized in shillings. Above £5 they are visualized in pounds, just like ordinary numbers.”

One important feature of this form is that the numbers themselves are not seen, their position only being visualized. This may be connected with the fact that the form carries relative as well as absolute values. The same point in space may represent, in different contexts, 17, the age of adolescence, the XVIIth Dynasty or one-and-fivepence.

The negative values are represented by a mirror-image of the number-form. This extends behind the head. When learning algebra, the use of this form obviated any difficulties in grasping the conception of adding to, or subtracting from, positive numbers, numbers of negative value.

After making a wire model of his number-form, and discussing it at the meeting of a scientific society, Prof. Tattersall requested me to add a note that closer acquaintance with and analysis of his number-form had persuaded him that the loose term semi-circle should be replaced by “ $\frac{3}{4}$  circle.” He writes : “ Semi-circle is perhaps not strictly accurate. On analysis, the part-circles, on which the groups of ten are arranged, are obviously the original clock-face with the portion from 10 to 1 left out, and are therefore  $\frac{3}{4}$  circles.” He also points out the interesting fact that his number-form became unconsciously adapted to increasingly complex figures as they became known to him. But as these notes were made some time after he became scientifically interested in his own number-form, he requests me to keep them separate from the original description.

This visual representation in space of the negative numbers is an interesting aspect of the question which seems to have been insufficiently studied. One of my correspondents, whose form, in most respects, is quite a usual one, has “ not a

1. (Added subsequently.) “ 1,000,000 has the same position as 10.”

definite line, but a sense of division " between zero and  $-1$ , and is then "conscious of numbers up to  $-10$  being there." The minus figures, she writes, "are very indistinct and in darkness; for some reason I connect all below 0 with Hell." This condensation of a numerical with an eschatological meaning illustrates a trait rather unusual in number-forms; the usual characteristic of this class being, to use a popular expression, "to keep themselves to themselves." The discovery of the reason for this exclusiveness might cast more light on the relation between image and meaning.

### *The Development of Number-forms.*

According to G. E. Müller, persons have been observed in whom a number-form existed before the knowledge of numbers, and before its possessor could read. He suggests that the new direction so often taken at 10, 20 or another low number, may be due to the development of the form beginning at the time when the child learns to count, and ending when he has achieved the performance of counting up to 100. Yet forms certainly exist which, arising in early childhood, were subsequently supplemented or modified under the influence of new needs or ways of living: Flournoy (2) mentions one which appeared in the 17th or 18th year of life.

The effect upon a number-form of the passage of time is interesting in many ways. Galton, when he described these phenomena in 1883, had few data upon which to base any general statement. He quotes Colonel Yule, who writes that he found his number-form to have become sensibly weaker in later years: "It is now faint and hard to fix" (3, 95). But in 1919 Professor Sir Arthur Schuster, F.R.S., whose number-form was described by Galton (3, 94-95; Pl. I, Fig. 21) in 1883, kindly sent me the following answers to my questions.—

(a) Has the number-form changed at all between 1883 and 1919?

"I find no change."

(b) Has the number-form become sensibly weaker in later years?

"My impression is that the vividness simply depends on use. When I work much with figures, and more especially with questions that involve historical dates, as I had to do recently, the form is as vivid as ever it was. For centuries in historical dates I depend on associations. I would think of Leonardo da Vinci, Galileo, Newton, as the case may be. The result is that I frequently make a

mistake in the century when suddenly called upon to give a date, and also by a year or two, as I have to work by the diagram."

This fact, that the vividness of the diagram depends upon the use made of it, is brought out by another of my contributors, a business man, who tells me that numbers which he habitually uses, *e.g.*, 15 (for  $1/3d.$  per yard), stand out more brightly than the others. An absence from business through illness caused the numbers to become dim.

### *Their Utility.*

The supposition is erroneous that all possessors of number-forms necessarily use them whenever they think of a number or set of numbers. Galton's original statement (3, 82),<sup>1</sup> "(the peculiarity) consists in the sudden and automatic appearance of a vivid and invariable 'Form' in the mental field of view *whenever* a numeral is thought of, . . ." would naturally tend to deepen such a belief. But the number-form described on pp. 3-5 is not used when the day of the month or degrees of latitude and longitude are thought of; in these cases there appear visual images of a wall calendar or of a map, on Mercator's projection. And as Flournoy has shown, a number-form may be used by a person for one kind of operation (*e.g.*, writing down a series of figures) but not for another, such as thinking of a date. Moreover, the answers to questions concerning the utility of these forms show that many persons who possess them consider them to be useless. Calkins found that of 67 persons so questioned concerning the usefulness of number-forms both in mathematical operations and in remembering dates, 29 were sure they were useful, while 21 were sure that they were not. Of Phillips's 211 subjects, 97 declared that their number-form was useful in reckoning, 113 that it was neither useful nor harmful, and one that he was disturbed by it.

In this connection it is interesting to note that one of the examples in my own collection is an *algebra*-form. It consists of a vertical line with a horizontal line crossing it, the zero being at the point of intersection. Positive quantities are visualized as proceeding vertically upwards and negative ones downwards. There are no gradations on the lines other than those actually in use at the time. In thinking of  $a - b$  the subject feels that the  $b$  is pulling the  $a$  down, and the  $a$  pulling the  $b$  up. Frequently a circle appears round the zero point;

1. Italics mine.



the result of his addition and subtraction must then lie within that circle. He cannot do algebra without this form, and he possesses no number-form.

The tendency to visualize connected series of entities spread out in space is not confined to numbers. Calkins mentions "forms for piano-notes (squares) with lines for violin notes : and an interesting prayer-form, well remembered from the time when the progress from one part to another was always the passage from one part to another of the form."<sup>1</sup>

One of Lemaître's subjects (4) possessed 30 diagram-forms of different kinds ; one of Müller's saw, in the part of his year-diagram corresponding to the beginning of spring, a fair youth holding a staff decked with apple-blossom, and with apple-blossom in his hair.

### *The alleged heredity of number-forms.*

Upon this question there appears to have been not a little confused thinking and generalization from insufficient evidence ; even occasionally from evidence which is opposed to some of the conclusions drawn from it. It is therefore necessary to distinguish different senses in which number-forms might at any rate be conceived as transmissible by heredity. There might be handed down a general tendency to visualize, a more specific tendency to visualize numbers in space or an even more specific tendency to visualize a particular kind of number-form.

Galton believed in transmission not only in the second but also in the third sense mentioned above. He writes :—

" I have the strongest evidence of its (the peculiarity's) hereditary character after allowing, and over-allowing, for all conceivable influences of education and family tradition (3, 82). I give four instances in which the hereditary tendency is found, not only in having a Form at all, but also to some degree in the shape of the Form " (3, 100).

These tendencies which he conceives to be hereditary, he compares to the instincts of animals. He likens the "natural fancies for different lines and curves" of different persons to the universal tendency of each species of animal "to pursue their work according to certain definite lines and shapes, which are to them instinctive, and in no

1. The writer remembers, though unfortunately he has no written record of it, that a 'commandment-form' of a curious kind was once mentioned by a correspondent to the *Westminster Gazette*. Each of the ten Commandments was localized at some part of the correspondent's native village, e.g., one might be thought of as localized at the bridge, another as at the school door.



Yet on reference to his diagrams (3, 100; Pl. III), and to the explanations offered with them, the most which can be said is that while they suggest that the tendency to have a form may run in families, they accord no evidence of an hereditary tendency to have an identical or even a closely similar form. Moreover, on examining Plate III of the "Inquiries into Human Faculty," which is reproduced upon page 9 of the present paper, one is immediately struck by the unlikeness of the four forms possessed by the Henslow family (Figs. 46—49), and of Figs. 57 and 58 both from each other and from Figs. 55 and 56, though these later four all belong to the same family. The heading of Plate III, "Instances where the Number-Forms in same family are *alike*," seems then to be somewhat misleading, except in the case of the pairs 55 and 56 and 59 and 60, which we shall now consider.<sup>1</sup>

55 and 56, those of a father and son, are undoubtedly similar. Their chief differences are that while the general direction of one is horizontal, that of the other is vertical, and that one ends definitely at 100, while the other, ending at 99, appears to begin another form at 100.

59 and 60 are those of a brother and sister, less alike than the preceding pair, but certainly similar.

Before commenting further upon these pairs, however, we may examine a set of three number-forms supplied by three persons who are entirely unrelated (see page 3 of this paper). *Fig. C* (1) is Professor Tattersall's; *Fig. B* is the number-form of Professor S. J. Hickson, F.R.S., of Manchester; *Fig. A*, from the *American Journal of Psychology*, is that of an unknown person (1, 448). Neither of the first two contributors, when they communicated with me, had any idea that a similar number-form was possessed by a colleague,<sup>2</sup> nor, at that time, did either of them know of the existence of *Fig. A*, which I found while examining the literature on this subject, after the receipt of *Fig. C* (1) and before receiving *Fig. B*.

Most of the structural features of these three forms appear to be almost identical. Save for the presence of a gap after 12 in *Figs. B* and *C* (1), and its absence in *Fig. A*, the salient features of the forms are the same. The direction of the line between 10 and 20 varies, and, while it is definitely curved in

1. The likeness of 53 and 54 cannot be accepted as convincing evidence in this connexion, since 54 is not figured, but only described as "nearly the same (as 53) except that the first change of direction is at 10."

2. At this time, Prof. Tattersall was at the University of Manchester.

*Fig. B*, it is slightly curved in *Fig. A* and straight in *Fig. C* (1). The extents of the forms are not identical.

The chief difference between the forms is that while *Fig. C* (1) emphatically tri-dimensional, and for its possessor this is one of its most important features, *Fig. B* is almost in one plane, while concerning *Fig. A* no relevant data on this point have been given. Yet, having pointed out these differences, it seems justifiable to hold the opinion that the degree of resemblance between these three compares very favourably with that of most of the 'similar' pairs adduced by Galton in support of his belief. It might be emphasized that not only has this trio been obtained from entirely unrelated people, but that the coincidence is of three and not of two cases; a fact significant in itself. Moreover, a glance at Numbers 20<sup>1</sup> and 2 of the forms in Plate I of the *Inquiries* will show that these two latter are not very unlike the three figured above; and that No. 37 in Plate II, though an elaborate structure, contains the essentials of these three forms.<sup>2</sup>

The possessor of *Fig. A* in the above collection of three forms definitely attributes the chief feature of his form to a post-natal cause; the perception of a clock. He says:—

“I cannot explain the origin of the almost straight lines between 12 and 20, but the curves came from the fact that I learned to tell time before I learned to count, and when I did learn, everything reverted to the picture of that old clock.”

Prof. Tattersall writes, after having read this explanation:—

“The semi-circles in my form are, I suppose, the remains of the clock face, and this would explain why 6 is always the lowest figure in a semi-circle. For instance, I told you 36 was the farthest away to my left. Well, of course, 36 is the lowest figure in its semi-circle.

“I think my form is undoubtedly derived from the clock-face, and I have always thought so. It is of course a very simple number-form and might very reasonably be

1. That of Mr. George Bidder, Q.C., the son of a famous calculator, and himself able to multiply mentally fifteen figures by another fifteen figures. In the present connexion the gap in his form after 12 is interesting, as it corresponds to those of *Figs. B* and *C* (1), which have just been mentioned.

2. Note, too, that it shows the gap after 12.



explained on the 'earliest recollection' theory. I know I was much fascinated by clocks and watches as a child and I could tell the time almost as soon as I could talk."

Yet another objection to Galton's assumption arises when the chief turns in number-forms are examined. Calkins found that three-fourths of the turns were at numbers which are prominent in early arithmetical exercises and in ordinary usage. One of my contributors writes of her number-form, which she calls a "figure-board":—

"My figure-board changes at tens, except at the first 12 where there is a rather indistinct modification of the line. I am not English born, but French-Swiss, and all my arithmetical calculation has been based upon the decimal system. Do you think the duodecimal system as used here may affect the figure-board of English people?"

Detailed evidence has now been obtained that very complicated objects in a person's environment may give rise to number-forms, which can be traced definitely and completely to their influence. Hennig (4) shows that both his own number-form and that of his brother were essentially determined by the arrangement and illumination of the houses in the Potsdamer Strasse in Berlin. The house-numbers in the street had particularly interested them when they lived there in early childhood. The number-form of another brother was attributable to the pathways and numbers in the Berlin Zoological Gardens, which he often visited. Phillips mentions a child who, when five years old, could add numbers only when he was in a room with a clock, the hour-spaces of which he counted. At the age of 7 this child "used the clock-face mentally." To all this evidence may be added the fact that in some number-forms the negative values are represented; this renders any simple belief in their hereditary character quite untenable.

The most, therefore, that can justifiably be believed concerning the possible heredity of number-forms is that the tendency to visualize may be handed down, transmitted, maybe, in purely physiological terms as an inheritance of a specially favourable neural basis in the brain. Yet in the way of even this simple belief there lie some formidable obstacles. It is quite clear that the power of visualization can be greatly strengthened by practice. Galton himself lays stress upon



this fact (3, 73f), and Dr. J. Varendonck has recently recorded his own progress in this respect (5, 90).

“ I have even noticed of late that when I happen to read poetry now I am able voluntarily to transform the poet's words into visual images, which adds a hitherto unknown charm to the reading.”

It seems, indeed, quite possible that any kind of imagery, even that in which a man may consider himself to be very poor, may be enormously developed during life, so that the facts seem to justify little more than the belief that congenital differences in visualizing power may be significant.

*The progressive complication of the functions of number-forms.*

In books upon the general theory of psychology little attention seems to have been paid to the significance of the number-form as an excellent ‘objectifiable’ example of a vehicle of simple or complicated meanings; an example, moreover, the nature of which can be made plain to other people. An examination of these forms illustrates clearly the different degrees of complexity which the ‘image-meaning’ relation may reach. The simplest representation of quantities by the number-form occurs when the actual numbers are seen arranged in fixed spatial relations. Rather more complex is the representation when the numbers are not visualized but only thought of, their positions in space being seen mentally. At a third stage these positions themselves acquire a relative as well as an absolute significance, when the actual quantity attributed to any position may be merely a special instance of some more general meaning.

Such a use of his number-form is often made by Prof. Tattersall. Any position on the form, though absolutely fixed in space, may represent any one of a large number of related quantities, or even the subject or theme of which a particular quantity is merely one characteristic.<sup>1</sup> Such a form, representing almost any kind of related quantity, has reached another stage in a line of development which, if continued, would lead through infinite gradations to the formation of an image which carries the unquantitative essence of mathematical conceptions. A very high position in this scale of evolution

1. An example of this variability of meaning of a fixed point on a number-form has been given on p. 5.

must be occupied by Professor Einstein's illustration of a large sphere tenanted by exceedingly small beetles, with which he has recently illustrated his conception of a finite but unbounded space.

#### BIBLIOGRAPHY.

1. CALKINS, M. W. *Amer. Jour. of Psychology*, 1892-3. **5**, 439—464.
2. FLOURNOY, T. "Des phénomènes de Synopsie." Paris, 1893.
3. GALTON, F. "Inquiries into Human Faculty and its Development." 1st edition, 1883. Subsequently reprinted in *Everyman's Library*. (The references in this paper are to the pages of the later edition.)
4. MÜLLER, G. E. "Zur Analyse der Gedächtnistätigkeit und des Vorstellungsverlaufes." Leipzig, 1913. Pt. III, 72—131.
5. VARENDONCK, J. "The Psychology of Day-dreams." London, 1921.

### III.—Scottish Pork Taboo.

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(Communicated by W. J. PERRY, M.A.)

(Read May 9th, 1922. Received for publication October 17th, 1922.)

JULIUS Cæsar informs us that Ancient Britain was densely populated; that the coinage was of copper and gold while bar-iron was used as a substitute for money; that the houses were very similar to those of Gaul, and that there were large flocks and herds. He states, too, that the inhabitants had a religious scruple against eating either the hare, domestic fowl or goose, although they kept these animals for amusement or as pets. The population on the south coast was Belgic while the inland parts were inhabited by a race which, according to its own traditions, was aboriginal (5, v, 12).

Cæsar's reference to the existence of food taboos is of special interest. Apparently these varied in different districts. Dion Cassius, writing of certain of the inhabitants of North Britain, informs us that although fish were abundant they refused to eat them (6, lxxvi, 12), which reminds us of Lucian's statement (19, chap. 14) that at Hierapolis, fish were sacred and not eaten, and that "amongst the Egyptians there are some who will not touch fish as food."

These ancient taboos are not yet entirely extinct. It is still possible to find Highlanders who decline to partake of what they call "feathered flesh" or "white flesh," and hare and rabbit. Almost all modern Scots taboo eel. In 1918 the Scottish Fresh-Water Fisheries Committee issued a pamphlet entitled "The Common Eel and its Capture; with suggestions applicable to Scotland," in which it is stated, "The prejudice which exists against the eel in Scotland is most unfortunate, since it prevents Scotsmen taking advantage of a most nutritious fish which appears to be well distributed throughout our waters. No doubt," adds the writer of this official pamphlet, "human beings have a natural aversion to creatures which have a writhing motion like that of a snake, while the fact that the eel is slimy as well as wriggling adds to the aversion, till

it becomes horror and loathing. The serpent is a symbol of the Devil, and all Highlanders know that the eel, being like a serpent, is like the symbol of the Devil, and is associated with the evil influence. People who can eat such creatures are, in his opinion, very far from particular in their feeding. The fact that many Continental peoples find the eel a most valuable food only shows that such foreigners will eat anything. The eel remains taboo."

The writer of the pamphlet then goes on to say that "some people in the West Highlands will not eat mackerel," and that others on the Solway, "till quite recently would not touch skate." Dogfish is not eaten in Scotland. I may remark here that this official pamphlet has not encouraged the eating of tabooed fish in Scotland.

Mackerel is supposed to devour human flesh, gorging on the decaying bodies of the drowned. They are reputed to be poisonous,<sup>1</sup> and especially so if caught in moonlight. Catfish and ling are tabooed still in some districts, as well as mackerel and dog-fish. Shell-fish and haddock must not be eaten when there is an "r" in the month. Haddocks should, in fact, get "three drinks of May water" before being caught, that is, they should not be fished for until after three May tides have ebbed and flowed. Eels are called "devil-fish." They are supposed to originate from the hairs of horses' manes and tails that have fallen into pools or rivers. Those who eat eel become mad and set out to fight with wild horses. Although "fish and the flesh of the boar and the badger" were freely eaten by the Irish Celts, some Irish and some Highland peoples used to dislike and despise the Saxons because they ate fish (2, 72). It may be that the Celtic military aristocrats ate food which was taboo to their pre-Celtic subjects. Perhaps that was why the salmon was in Ireland "considered food for Kings and nobles" (21, ccclxx).

Tabooed animals might, however, be eaten once a year in connection with a festival. The association of the goose with Michaelmas is of interest in this connection:—

"September, when by custom, right divine,  
Geese are ordain'd to bleed at Michael's shrine."

In the Highlands until recently goose was taboo except at Christmas. Birds are in Gaelic lore something more than birds. They may be forms assumed either by supernatural beings or enchanted men and women.

1. As a matter of fact, mackerel are poisonous when kept too long.

There were both individual and tribal taboos (the Gaelic "*geis*" or "*geas*"—plural *geasa*). It was *geis* to Cuchullin to eat dog's flesh; the first part of his name, *Cu*, signifies "dog." He was the "dog" of Culann, the Irish Vulcan.

Among the ancient *geasa* or taboos still surviving is Scotland none is of greater interest and importance than the one which forbids pork as food. The *geas*, or prohibition, has long since reached its final stage, surviving as a mere prejudice. Thousands of living Highlanders refuse either to keep pigs or to eat pork in any form. They despise pork as keenly as do the Hindus, the Jews, the Moslems and the modern Greeks of Northern Arcadia. Lord Leverhulme, who has seen or thought he has seen possibilities of development in the Lewis, recommended pig-rearing to the crofters and introduced swine into the island. In 1920 there were eight pigs in Lewis, which has a population of about 30,000; in 1921 there were only two. A native of Barra informs me it was a common saying in his boyhood that there had never been more than two pigs on his island; these had been washed ashore from a wreck and were promptly committed to the deep again. In my boyhood I heard pork referred to with aversion. Like mackerel, it was supposed to cause disease. I have eaten pork, but for the past few years the prejudice of my boyhood has revived to such an extent that I cannot any longer partake of pork in any form.

Ben Jonson had some knowledge of the Scottish pork taboo. In his "A Masque of the Metamorphosed Gypsies," a gipsy approaches the masqued King James and says:—

"Here's a gentleman's hand.

I'll kiss it for luck's sake: you should, by this line,  
Love a horse and a hound, but no part of a swine."

One of the gypsies had previously barred the inclusion of "grunterns," and Gifford, the annotator, explains this as "a side compliment to the King who hated pork in all its varieties." On another page, the Gypsies having made a reference to "a sow's baby in a dish," the annotator states in a footnote:—

"Three things to which James had a great dislike, and with which he said he would treat the Devil were he to invite him to a dinner, were a pig, a poll of ling with mustard, and a pipe of tobacco for digesture" (16, vol. vii, 372, 380, 420).



In Sir Walter Scott's "The Fortunes of Nigel," the Greenwich barber says to Nigel :—

"Sir Munko cannot abide pork, no more than the King's most Sacred Majesty, nor my Lord Duke Lennox, nor Lord Dalgarno . . . But the Scots never eat pork—strange that ! some folks think they are a sort of Jews."

In a footnote Sir Walter writes :—

"The Scots (Lowlanders), till within the last generation, disliked swine's flesh as an article of food as much as the Highlanders do at present."

In his memoir on his Hebridean tour, Dr. Johnson writes (15, 51) :—

"Of their eels I can give no account, having never tasted them, for I believe they are not considered as wholesome food . . . The vulgar inhabitants of Skye, I know not whether of the other islands, have not only eels, but pork and bacon in abhorrence; and accordingly I never saw a hog in the Hebrides, except one at Dunvegan. Rasay (an island adjoining Skye) has wild fowl in abundance, but neither deer, hares nor rabbits."

Mr. Robert Henderson, who was a farmer at Broomhill, near Annan, during the latter part of the eighteenth and the earlier part of the nineteenth century has written regarding "the prejudices so unjustly entertained against this species of stock (pigs)" in his native land (13, 80-82). "I have only now," he says, "to do away with the prejudices which exist with many against swine." Referring to the Egyptian and Jewish aversion to pigs he states with regard to the Scottish aversion: "Although permitted to Christians, yet there is still some degree of prejudice exists (existing) against them in the minds of many," including, he informs us, "that very foolish one concerning the devil in swine." He tells that in Ireland "it is a common practice for a cottager to keep a sow, which both eats and sleeps in the house with the family," and adds:

"I observed it mentioned some time ago, in the public papers, that a gentleman near London trained his swine to run in his carriage, and drove four in hand through London."

He makes the significant statement (13, 62):—

“The Scots in general, *particularly the lower classes*, are not fond of pork.”

John Graham Dalyell (7, 425) writes regarding the Scottish pork taboo:—

“In the year 1691 a question was put, ‘Why do Scotchmen hate swine’s flesh?’ and unsatisfactorily answered. ‘They might borrow it of the Jews.’ The same prejudice, though infinitely abated, still subsists. Yet it is not known that swine have been regarded as mystical animals in Scotland. Earlier in the seventeenth century, the aversion to them *by the lower ranks*, especially in the North, was so great, and elsewhere, and the flesh was so much undervalued that, except for those reared at mills, the breed would have been extirpated.”

Dalyell was evidently not aware that the pig was really what he would call a “mystical animal.”

In Sinclair’s “Statistical Account” the minister of Ardchattan and Muckairn, Argyllshire, writing c. 1792, says: “The deep-rooted prejudice against swine’s flesh is now removed.” The minister of Lesmahagow, Lanarkshire, is found stating: “The people of this part of Scotland had formerly a superstitious prejudice against swine.”

Captain Burt, writing about 1730, says (4, I, 118):—

“Pork is not very common with us but what we have is good. I have often heard it said that the Scots will not eat it. This may be ranked among the rest of the prejudices; for this kind of food is common in the Lowlands and Aberdeen, in particular, is famous for furnishing families with pickled pork for winter provision as well as their shipping.”

Burt was generalising from isolated and exceptional facts. Jamieson, his annotator, wrote in the 1818 edition:—

“The aversion of many of the Scots, both in the Highlands and Lowlands, to eating pork had nothing superstitious connected with it. They could not eat fat of any kind, not being accustomed to it.”

Jamieson was evidently quite ignorant regarding the lore connected with the pig.

Dean Ramsay (1793—1872) has provided important evidence regarding the Scottish prejudice against pigs (23, chap. 2):—

“ I am induced to mention the existence of a singular superstition regarding swine which existed some years ago *among the lower orders* of the East Coast of Fife. I can observe, in my own experience, a great change to have taken place amongst Scotch people generally on this subject. The old aversion to the ‘unclean animal’ still lingers in the Highlands, but seems in the Lowland districts to have yielded to a sense of its thrift and usefulness. I recollect, however, an old Scottish gentleman who shared the horror of the pig, asking very gravely : ‘ Were not swine forbidden under the law, and cursed under the gospel ? ’

The account given by my correspondent of the Fife swinophobia is as follows :—

‘ Among the many superstitious notions and customs prevalent *among the lower orders* of the fishing towns of the East Coast of Fife, till very recently, that class entertained a great horror of swine, and even at the very mention of the word. If that animal crossed their path when about to set out on a sea voyage, they considered it so unlucky an omen that they would not venture off. A clergyman of one of those fishing villages, having mentioned the superstition to a clerical friend, and finding that he was rather incredulous on the subject, in order to convince him told him he would allow him an opportunity of testing the truth of it by allowing him to preach for him the following day. It was arranged that his friend was to read the chapter relating to the herd of swine into which the evil spirits were cast. Accordingly, when the first verse was read, in which the unclean beast was mentioned, a slight commotion was observable among the audience, each one of them putting his or her hand on any near piece of iron—a nail on the seat or bookboard, or to the nails on their shoes. At the repetition of the word again and again more commotion was visible; and the words “cauld airn” (cold iron)—the antidote to this baneful spell—were heard issuing from various corners of the church. And, finally, on his coming over the hated word again, when the whole herd ran violently down the bank into the sea, the alarmed parishioners, irritated beyond bounds, rose and all left the church in a body.’ ”

The Rev. Alexander MacGregor, an Inverness clergyman, tells (20, 17) of a Skyeman, named Farquhar, who had "a superstitious dislike to bacon or pork." He had dinner at the Manse every Sunday.

"It frequently happened that the servant's dinner consisted of pork or bacon, the look of which Farquhar could not bear, and yet he often dined on it. The servants, knowing his prejudices, had beforehand prepared a quantity of the lean parts of the meat for the old man which they passed off as mutton and which he never suspected. When partaking of it, however, he frequently said, to the no small amusement and tittering of the domestics: 'Bu tu fein an fheoil, mhaith, cheart, agus cha b'i a' mhuc ghrannda, shalach' ('Thou art the good right meat, and not the filthy unclean pig')."

One of the oldest Scottish literary references to the Scottish pork taboo is that of Bishop Leslie in his *History* (1578) in which he says (Dalrymple's version):—

"As swyne flesh is uset in uthir countries of quhilke our cuntrie people has lytle plesure."

The fishermen of Cromarty, in my boyhood, refused to put to sea if when walking towards their boats they met a pig or a hare. If one happened to ask a fisherman "Where are you going?" he would exclaim: "Is that what you're saying?" turn on his heel and make for home again.

A middle-aged native of Wick, resident in Edinburgh, informs me that in his youth the Caithness fishermen forbade mention of a minister or a pig when at sea. If, in the course of conversation, a minister had to be mentioned he was referred to as "could-iron gentleman," while a pig was "the could-iron beastie."

The fishermen of a past generation in Newhaven (near Edinburgh) were greatly enraged when the mischief-making youngsters of Leith shouted after them, "There's a soo at the boo" ("There's a sow at the bow of the boat"). At Oban boys were wont until recently to enrage men from the island of Lismore by imitating the bleating of sheep. I have seen in the eighties of last century a Lismore boat turned back to the pier and its occupants coming ashore to chase the boys. The miners of Prestonpans, East Lothian, shared the fisherman's prejudice against pigs. They refused to descend a coal mine if on walking towards it they met a pig.



Mr. R. Blakeborough in his *Wit, Character, Folk-lore and Customs of the North Riding of Yorkshire*, writes (p. 141): "If whilst a fisherman was baiting his nets anyone mentioned anything in connection with a pig, or *dakky*, as it was called, the worst of luck would be looked for."

About the time Captain Burt was writing his letters from the North of Scotland and Aberdeen was exporting to Holland pickled pork for victualling East India ships (24, 198), a Dumfriesshire village was greatly stirred by the appearance of a pig. The following narrative is given by Mr. Robert Henderson (13, 15 *et seq.*):—

"Within the last century (probably about ninety years ago) a person in the parish of Ruthwell, in Dumfriesshire, called the 'Gudeman o' the Brow,' received a young swine as a present from some distant part; which, from all the information I could get, seems to have been the first ever seen in that part of the country. This pig having strayed across the Lochar into the adjoining parish of Carlavroc, a woman who was herding cattle on the marsh, by the sea-side, was very much alarmed at the sight of a living creature that she had never seen nor heard of before, approaching her straight from the shore as if it had come out of the sea, and ran home to the village of Blackshaw screaming. As she ran it ran snorking and grunting after her, seeming glad it had met with a companion. She arrived at the village so exhausted and terrified, that before she could get her story told she fainted away. By the time she came to herself a crowd of people had collected to see what was the matter, when she told them that 'There was a diel (devil) came out of the sea with two horns in his head (most likely the swine had pricked ears) and chased her, roaring and gaping all the way at her heels, and she was sure it was not far off.'

A man, called Will's Tom, an old schoolmaster, said if he could see it he would 'cunger the diel,' and got a bible and an old sword.

It immediately started up at his back and gave a loud grumph, which put him into such a fright that his hair stood upright in his head, and he was obliged to be carried from the field half dead.

The whole crowd ran, some one way and some another; some reached the housetops, and others shut themselves in barns and byres. At last one on the housetop called out it was 'the Gudeman o' the Brow's grumphy,' he having



seen it before. The affray was settled, and the people mostly reconciled, although some still entertained frightful thoughts about it, and durst not go over the door to a neighbour's house after dark without one to set or cry them. One of the crowd who had some compassion on the creature, called out, 'Give it a tork of straw to eat; it will be hungry.'

Next day it was conveyed over the Lochar, and it seemed to find its way home. It being near the dusk of evening it came grunting up to two men pulling thistles on the farm of Cockpool. They were much alarmed at the sight, and mounted two old horses they had tethered beside them, intending to make their way home. In the meantime the pig got between them and the houses, which caused them to scamper out of the way and land in Lochar moss, where one of their horses was drowned, and the other with difficulty relieved. The night being dark they durst not part one from the other to call for assistance, lest the monster should find them out and attack them singly; nor durst they speak above their breath for fear of being devoured. At daybreak next morning they took a different course, came by Cum-longon Castle and made their way home, where they found their families much alarmed on account of their absence.

They said they had seen a creature about the size of a dog, with two horns in its head, and cloven feet, roaring out like a lion, and if they had not galloped away it would have torn them to pieces.

One of their wives said, 'Hout, man! it has been the Gudeman of the Brow's grumphy; it frightened them a' at the Blackshaws yesterday, and poor Meggie Anderson maist lost her wits, and is ay out o' ae fit into anither sin-syne' (since then). The pig happened to lie all night among the corn where the men were pulling thistles, and about daybreak set forward on its journey for the Brow. One Gabriel Gunion, mounted on a long-tailed grey colt, with a load of white fish in a pair of creels swung over the beast, encountered the pig, which went nigh among the horse's feet and gave a snork.

The colt, being as much frightened as Gabriel, wheeled about and scampered off sneering, with its tail on his riggin, at full gallop.

Gabriel cut the slings and dropt the creels, the colt soon dismounted his rider, and, going like the wind, with his tail up, never stopped till he came to Barnkirk point, where he took the Solway Firth and landed at Bowness on the Cumberland side.

As to Gabriel, by the time he got himself gathered up, the pig was within sight; he took to his heels, as the colt was quite gone, and reached Cumlongon wood in time to hide himself, where he stayed all that day and night, and next morning got home almost exhausted. He told a dreadful story! The fright caused him to imagine the pig as big as a calf, having long horns, eyes like trenchers (plates), and a back like a hedge-hog. He lost his fish, the colt was got back, but never did more good, and as to Gabriel, he soon after fell into a consumption and departed this life about a year after.

About this time a vessel came to Glencaple quay, a little below Dumfries, that had some swine on board, most likely for the ship's use; one of them having got out of the vessel in the night, was seen on the farm of Newmains next morning. The alarm was spread, and a number of people collected. The animal got many different names, and at last it was concluded to be a brock (badger). Some got pitchforks, some clubs, and others old swords, and a hot pursuit ensued; the chase lasted a considerable time, owing to the pursuers losing heart when near their prey and retreating. Rob's Geordy, having rather a little more courage than the rest, ran 'neck or nothing' forcibly upon the animal, and run it through with a pitchfork, for which he got the name of 'stout-hearted Geordy' all his life after. There is an old man, nearly a hundred years of age, still alive in the neighbourhood where this happened, who declares that he remembers of the Gudeman of the Brow's pig, and the circumstances mentioned; and he says it was the first swine ever seen in that country."

In this narrative it will be noticed (1) that the wild pig had disappeared in Dumfriesshire, and (2) that the pig was regarded as a devil.

The Gaelic-speaking people of Scotland have many names for the devil, one being "The Big Black Pig" (*muc mhòr dhubh*). When the devil appeared in human form he had "usually," writes the Rev. John Gregorson Campbell, Tiree, "a horse's hoof, but also sometimes a pig's foot." He was in the habit of visiting young people who played cards.

"Cards are notoriously known as the devil's books. When boys play them the fiend has been known to come down the chimney feet foremost, the horse's or pig's foot appearing first. When going away he disappears in smoke and neighs horribly in the chimney" (31, 290-2).

The Highland crofters in some parts of the Hebrides began to keep pigs after Dr. Johnson's day, but for one reason or another, and chiefly because of the prevailing prejudice against the animal, pig-rearing was abandoned. In Skye the superstitious abhorrence of the pig was revived as a result of a tragic occurrence. A hungry pig wandered into a house and killed and partly devoured a baby in a cradle. I heard this tradition when in Skye a few years ago. "Who," said a native to me, "would eat the flesh of an animal which devours human beings?"

Although the pig was generally associated with the devil, there is Highland evidence which suggests that it might, as a supernatural being, be, like the fairies, of assistance to mankind. An interesting story, also related by Gregorson Campbell, connects the pig with the fairies (Gaelic *sithchean* = supernatural beings). It relates to the belief that seed corn might be increased by working spells and sowing in silence. If the sower is spoken to the supply of seed corn suddenly goes down. Campbell's story is as follows:—

"A man in the Ross of Mull, about to sow his land, filled a sheet with seed oats, and commenced. He went on sowing but the sheet remained full. At last a neighbour took notice of the strange phenomenon and said, 'The face of your evil and iniquity be upon you, is the sheet never to be empty?'

When this was said a little brown bird leapt out of the sheet, and the supply of corn ceased. The bird was called *Torc Sona*, i.e., *Happy Hog* (more correctly *Happy Boar*), and when any of the man's descendants fall in with any luck they are asked if the *Torc Sona* still follows the family" (31, 99).

The Lucky or Sacred White Boar figures in one of the legends associated with Glasgow's patron saint, St. Kentigern (St. Mungo). Joceline, a monk of Furness, relates that when "the most holy Kentigern" was in Wales he "found a place fit for building a tabernacle (monastery) to the Lord, the God of Jacob," by following a white boar. Followed by "a great crowd of his disciples" Kentigern had wandered over hills and through valleys and forests,

"when lo and behold a single wild boar from the wood, entirely white, met them, and approaching the feet of the saint, moving his head, sometimes advancing a little, and

then returning and looking backwards, motioned to the saint and to his companions, with such gesture as he could, to follow him. On seeing this they wondered and glorified God, who worked marvellous things, and things past finding out in His creatures. Then step by step they followed their leader, the boar, which preceded them.

When they came to the place which the Lord had predestinated for them, the boar halted, and frequently striking the ground with his foot, and making the gesture of tearing up the soil of the little hill that was there with his long tusk, shaking his head repeatedly and grunting, he clearly showed to all that that was the place designed and prepared by God " (28, 75-6).

A similar story is told regarding the Thane of Cawdor. Before he erected Cawdor Castle he had a dream in which he was instructed to place his treasure chest upon an ass and to build the castle on the spot where the ass lay down. An iron treasure chest and a hawthorn tree still preserved in the castle dungeon are connected with the legend. Black Duncan of Cowl, the laird of Glenorchy in Perthshire, erected Balloch Castle (afterwards called Taymouth Castle) on the spot where, as he had been advised, he should first hear the blackbird sing as he went down the strath. In the Indian *Mahábhārata* the horse intended for the great horse sacrifice (*Ashwamedha*) was set a-wandering for a year. It was followed by an army, which conquered each state into which the animal wandered or received the submission of the rajah. The extent of the Maharajah's Empire was fixed by the wandering horse. The British Queen Boadicea, it will be recalled, drew auguries from the movements of a hare. The devil-pig and the god-pig are met with on the sculptured stones of Scotland.

On the Ruthwell Cross, Dumfries, Christ stamps on the pig instead of on the asp or basilisk forms of the devil.

The god-pig is represented on the " Boar Stone " situated at the margin of a field on the farm of Knocknagael (" Hill of the Hostages "), near Inverness. A figure of a wild boar with tusks and bristles on its back is finely incised in outline on this stone. Above its head is the well-known sun symbol. Evidently it was originally the " Boar of the Sun " or the " Boar of Heaven." The god boar was connected with the Witham shield on which " coral is unmistakable and in excellent condition "; it originally had " a bronze badge of that animal affixed to the front by rivets." Bronze boars in the round have been found at Hounslow. " It is possible,"



writes Sir Hercules Read, "that some, like that of Guilden Morden, were crests of helmets. The boar frequently occurs on British and Gaulish coins of the period and examples have been found as far off as Gurina and Transylvania. In the same field at Hounslow was found the bronze wheel with four spokes and a diameter of  $1\frac{1}{2}$  inches like another from Colchester. A wheel of the same character belongs to the Stanwick find, but has a rectangular loop at the back; and all may have been connected with sun-worship. It was more probably as a religious symbol than as a survival of the chariot wheel or a form of currency, that the wheel occurs on the coinage of Gaul and Britain" (3, 87 *et seq.* + 135-6).

Cuchullin rolls a wheel and throws an apple when crossing the Plain of Ill-luck on his way to the dun of Scathach (14, 74). The Gauls had a pig-god called Moccus (Scottish *muc*, a pig, Irish *mucc*, Welsh *moch*). "The wild boar, too," says Anwyl, "was a favourite emblem of Gaul, and there is extant a bronze figure of a Celtic Diana riding on a boar's back" (1, 30).

Of special interest is Tacitus's reference to the pig-worshipping Baltic amber-traders, the Æstyans. In his work on the Germans he writes of this people (chap. xlv.) :—

"In their dress and manners they resemble the Suevians (Swedes), but their language has more affinity to the dialect of Britain. They worship the mother of the gods. The figure of a wild boar is the symbol of their superstition; and he, who has that emblem about him, thinks himself secure even in the thickest ranks of the enemy, without any need of arms, or any other mode of defence."

Evidently the boar was the son of the Sow mother goddess who was connected with amber as the British boar god of the Witham shield was with coral. Freyja, the northern goddess, gave origin to amber, gold, etc., by weeping tears that coagulated. The Swedes made in February, the month sacred to her, boars of paste which they ate.

Louis Siret has shown (17, 290) that the Easterners who settled in Spain before the introduction of bronze working and extracted ores from its mines imported amber from the Baltic and jet from Britain. They worshipped the mother goddess as did the Æstyans. Among the peoples who acquired the art of navigation from them were those known later as the Pictones. These seafarers and traders colonized Orkney and Shetland and passed thence to the mainland of Scotland. They were known as the Picts. Professor W. J. Watson has shown



(33) that the Picts were divided into two clans called the Orcs (Young Boars) and the Cats. He quotes the following significant statement from the Gaelic "Book of Ballymote":

"Cairnech was for seven years in the sovereignty of Britons, and Cats, and Orcs and Saxons."

"Inse Catt" (Islands of the Cats) was Shetland, and "Inse Orcc" (Islands of the Boars) was Orkney. Prof. Watson writes:—

"Though Ptolemy does not mention by name the tribe who inhabited Orkney, their name may be inferred with fair certainty from the names Orcas, Orcades. The adjective Orcas is formed from a noun Orcos, which, as has been pointed out by Macbain and others, is a Celtic word represented in Irish by *orc*, a young boar, and cognate with Latin *porcus*, a pig. From this again comes Orcades, the Boar Isles, formed like Cyclades, Sporades, Echinades and other Greek names for island groups" (33, 23).

The "Cats" gave their name to Caithness, and to the inhabitants of that county and of the county of Sutherland. The Duke of Sutherland is still referred to in Gaelic as "Duke of the Cats." Clan Chattan is the "Cat clan."

Another Scottish pig locality is Banff. This place-name is derived from the Gaelic *banb* (pig), Welsh *banw*. The pig had several Celtic names.

We have found that the pig-god might assume a bird form and cause seed-corn to multiply. The Orc (Young boar) had similarly a number of transformations. In old Irish *Orc* is a name for the salmon, while *Oircne*, the diminutive form of *Orc*, was applied to a particular kind of lap dog. *Orc* also signified an egg. As Hathor was "House of Horus," the egg may have been regarded as the "house" of the boar god. Another pig-name was "cribuis" and the "cribus mara" was the porpoise. The whale remains to be added to the Old Celtic mythological museum. One of its Celtic names is *orc*. It was known to Milton who has a line in "Paradise Lost" (Book xi, line 835) referring to

"The haunt of seals, and orcs, and sea-mews' clang."

The common people, in their everyday superstitions, and children in their games, perpetuate beliefs and customs of great antiquity, and even the memory of beliefs and customs

that have long lost their significance. My friend, the late Rev. Dr. George Henderson, with whom I have discussed the Scottish treatment of the pig, has written in a footnote :—

“ I noted a children’s game in Eriskay (Hebrides) called *Mathair Mhór*, ‘ Big Mother,’ where the mother was feigned to be a pig ! It is possibly a relic of early ritual.” (12, 24-5).

In Wales the mother pig is associated with Halloween, the festival at which the life-prolonging apples and hazel-nuts play so prominent a part. There the Black Sow of All-Hallows, as the late Sir John Rhys, Oxford, once wrote to me, “ is the very devil.” In his “ Celtic Folklore ” he shows that the English expression, “ the devil take the hindmost,” is in the Welsh of Carnarvonshire “ may the black sow without a tail seize the hindmost.” “ The cutty black sow is often alluded to nowadays to frighten children in Arfon.” The verse “ A cutty black sow on every stile, spinning and carding every Allhallows Eve,” is in Cardiganshire different. There the sow becomes “ a bogie on every stile.” (26, i, 225-6.)

The “ mystic pig ” was known in Ireland. Miss Eleanor Hull, writing in *Folklore* (1918) on “ The Black Pig of Kil-trustan,” has shown that “ the hunt of magical boars or swine is the theme of many tales ” in Ireland and Wales. She states that “ nearly all the enchanted swine were transformed human beings,” and that “ they were connected with the earliest race of deified beings, Manannan, Lugh, Lir and Angus, and that they were usually slain in Connaught.” She notes that “ in the Late Celtic period the figure of a boar was used as a decoration, and small figures of the animal in bronze have been found in Ireland ; one is preserved in the National Museum, Dublin.” An Irish manuscript story states that “ pigs of magic came out of the cave of Cruachan, and that is Ireland’s gate of hell . . . Round whatever they used to go, till the end of seven years, neither corn nor grass nor leaf would grow through it ” (25). The pork taboo appears to have obtained at one time in certain areas in Ireland. From enquiries which I made among livestock dealers with whom I once travelled from Dublin to Belfast, there are still families in Ireland whose members refuse to eat pork. The great proportion of the Irish people, however, know nothing regarding the pork taboo.

The Continental Celts, like the Achæans who over-ran Greece, were pig-rearers and pork eaters. Poseidonius of

Apamea (quoted by Strabo. iv. c. 4 § 3) states that the Celts "have so many sheep and swine that they supply *saga* and salted pork in plenty, not only to Rome, but to most parts of Italy . . . . They live on milk and all kinds of flesh, that of swine, which they eat both fresh and salted, being the most common."

Dr. Sullivan, in his introduction to O'Curry's "Manners and Customs of the Ancient Irish," shows that the Irish Celts regarded pork as a great delicacy. They cured hams "in the smoke of greenwood, such as beech, ash, and white thorn."

"The general name for bacon was *Tini*, but smoke-cured hams and flitches were called *Tineiccas*. This is almost identical in form with the Gallo-Roman word *Taniaccæ* or *Tanacæ*, used by Varro (116-27 B.C.) for hams imported from Transalpine Gaul into Rome and other parts of Italy. Puddings prepared from the blood of pigs also formed an article of export from Gaul to Italy, as we learn from Varro. Puddings of the same kind were also made by the Irish." (21, ccclxix, *et seq.*).

It no doubt comes as a shock to those who have been of late years viewing the Celt through the coloured spectacles supplied by Renan, and Arnold and by the exponents of the Neo-Celtic school of poetry, to find the so-called dreamy Celt of their imaginations appearing at the dawn of Western European history as a greasy pork merchant.

The eastern wing of the Celts was in Asia Minor and gave their name to Galatia. According to Hieronymus of Cardia, (quoted by Pausanias, 1, 3 § 5), "the name Galatia is of late origin, for originally they were called Celts, both by themselves and by all other peoples." They were eaters of pork to begin with, but ultimately tabooed it. The explanation given for the change of diet is contained in the following significant passage:—

"Thereupon Attis himself and several of the Lydians were slain by the boar, in consequence of which the Galati who dwell in Pessinus will not eat swine" (*op. cit.*, vii, 17).

Lucian (2nd century A.D.), writing of the Galli (19, chap. 54), says:—

"They sacrifice bulls and cows and goats and sheep; pigs alone, which they abominate, are neither sacrificed nor eaten. Others look on swine without disgust, but as holy animals."

Sir Wm. Ramsay shows that the river Halys still separates the pig-god people from the pig-demon people (22, 32).

The Eastern wing of the Celts had come under the influence of the Attis cult. Attis, like Adonis, had been killed by a boar. Now, the Western wing of the Celts was in Scotland. Apparently those Celts who in Scotland ceased to keep pigs and eat pork had been similarly influenced by a non-Celtic religious cult which tabooed pork. Nothing short of a change in religious beliefs could have accomplished so great a revolution in the habits and beliefs of the Continental Celts who reached Scotland. The Scottish and Irish Diarmid who was killed by a "magic boar" is the Western representative of Attis-Adonis.

Some writers have suggested that the Scottish hatred of swine and the fear that the eating of pork will result in various diseases, was "borrowed from the Jews"—that, in fact, the taboo had origin in early Christian times, pork being found to be tabooed in the Old Testament, while Christ caused the demons to enter the bodies of Gadarean swine. This hypothesis will not stand investigation. If the early Christians tabooed pork in Scotland, why were pigs kept at monasteries and pork eaten by the clergy, and why was pork not tabooed in England and in Ireland? The Scottish pork taboo had evidently its origin in pre-Christian times. It was a prejudice based on superstition, and, as it survives to-day, this prejudice is still connected with superstitions. The superstitions of our own time were formerly religious beliefs. Those who contend that the Scottish prejudice against pork was "borrowed from the Jews" have to explain why one tabooed animal was selected and another overlooked. In Isaiah (Chapter lxvi, verse 17) we read, "They that sanctify themselves and purify themselves in the gardens behind one tree in the midst, eating swine's flesh, and the abomination and the mouse, shall be consumed together, saith the Lord." The early inhabitants of Scotland observed ceremonial mouse feasts (25), and the liver of the mouse was until recently a folk remedy for children *in extremis*, while roasted mouse was a cure for whooping cough and small-pox. This mouse cure was of Eastern origin (29, 43) and was prevalent in England as well as in Scotland (11, 94-96).

In Leviticus (Chapter xi, verses 6 and 7) the animals which are tabooed include the hare and the pig:

"And the hare, because he cheweth the cud, but divideth not the hoof; he is unclean to you. And the swine, though



he divided the hoof and be cloven-footed, yet he cheweth not the cud ; he is unclean to you."

As we have seen, Julius Cæsar found that the Ancient Britons tabooed the hare (5, v, 12). No one can seriously suggest therefore that the lingering prejudice against hares and rabbits in the Highlands and elsewhere is of early Christian origin. Those who contend that the prejudice against pigs is connected with the cloven hoof, overlook the fact that there existed in Scotland a breed of pigs which had undivided hoofs. "I have lately seen," wrote Mr. Robert Henderson, the Annan farmer, in 1811, "hogs of a black colour, at the Earl of Moray's, at Dennibirsel, that have close feet like a horse, instead of being cloven-footed" (13, 25)

The theory that the Scottish prejudice against pork arose from a desire to observe strictly the Mosaic law in this connection is evidently of comparatively recent origin. To the masses of the early Christians the Bible was a closed book. Even although translations in English and Gaelic had been available, few could read. There were illiterates, too, even among the clergy as Scottish historians have shown. Evidently the Biblical explanation of the Scottish pork taboo is a secondary one, originally urged by some pious patriot who tried to account for the persistent hatred of the pig in his native land. The fact that one of the old Gaelic names of the pig, in "O'Davoren's Glossary," is *deil*, may here be noted. In the Lowland Scots dialect "*deil*" is "*devil*."

The Finns, like the early people of Scotland, tabooed pork. In their case a Biblical origin for the prejudice has never been suggested. The *Skrifter* (1910) of the Norwegian Society of Sciences, contains an article on the "Primary Source of Lapp-landish Mythology." We are informed that "Finns do not eat swine because these are their horses when they fare in their spiritual troll visions to fight against other Finnish sorcerers (Ganfinnir). Those who eat or have eaten swine have then no horse, and become vanquished" (35, 15). Here we seem to meet with the pig *avatar* of a deity of the ancient folk.

The ancient pork taboo still survives in a part of Greece among a people of non-Hellenic origin whose ancestors must have effected an intellectual conquest of the pork-eating Achæan intruders, as did the pork-hating Anatolians of the intruding Celts who settled in Galatia and the pork-hating people of Scotland of the earliest Celtic intruders.



J. G. Lawson (18, 87-8) contributes the Greek evidence :—

“ In Northern Arcadia I also learnt that the flesh of the pig, in respect of which the ordinary Græculus fully deserves the epithet *esuriens*, is taboo; and the result of eating it is believed to be leprosy. It might be supposed that this superstition has resulted from contact with Mohammedans; but such an explanation would not account for the confinement of it to one locality—and that a mountainous and unprofitable district where intercourse with the Turks must have been small; and further the Greek would surely have found a malicious pleasure, the most piquant of sauces, in eating that which offended the two peoples whom he most abhors, Turks and Jews. On the other hand, if we suppose the fear of swine’s flesh to be a piece of native tradition, its origin may well be sought in the ritual observances of the cult of Demeter and her daughter, to whom the pig was sacred and in whose honour it was sacrificed once only in each year, at the festival of Thesmophoria (Schol. in *Ar. Ran* 441. *Ælian, Hist. Anim.*, v, 16). There are many instances among different peoples of the belief that skin diseases, especially leprosy, are the punishment visited upon those who eat of the sacred or unclean animal; for the distinction between sacred and unclean is not made until a primitive sense of awe is inclined by conscious reasoning in the direction either of reverence or of abhorrence (9, 44 *et seq.*). Thus in Egypt, the land from which the Pelasgians, if Herodotus (ii, 171) might be believed, derived the worship of Demeter, it was held that the drinker of pig’s milk incurred leprosy (*Ælian, loc. cit.*); and we may reasonably suppose that the same punishment threatened those Egyptians who tasted of pig’s flesh, save at their one annual festival when this was enjoined (Herod., ii, 47; Plutarch, *Isis et Osiris*, 8; Moral, 354; *Ælian, loc. cit.*). Now the Thesmophoria resembled the Egyptian festival in that it was an annual occasion for sacrificing pigs and for partaking therefore of their flesh; if then the worshippers of Demeter, like the Egyptians, were forbidden to use the pig for food at other times, and if the penalty for disobedience in Greece too was believed to be leprosy, the present case of taboo in Arcadia—the only one known to me in modern Greece—may be a survival from the ancient cult.”

The annual pig feast may have been held once a year in ancient Scotland. As much is suggested by a statement made

in the "Statistical Account of Scotland, 1793" (xvi, 460), with reference to the parishes of Sandwick and Stromness, Orkney :

"In a part of the parish of Sandwick, every family that has a herd of swine, kills a sow on the 17th day of December, and thence it is called Sow-day. There is no tradition as to the origin of this practise."

In the Whitley Stokes edition of "Three Irish Glossaries (London, 1862, p. 1 of preface) the editor refers to "lupait," and says it is explained as "the name of the pig that was killed on Martin's festival, and it seems to me" (added the ancient commentator quoted by Stokes) "it was to the Lord it was offered."

The Egyptians, according to Herodotus, sacrificed the pig to the moon and to Osiris. "The poorer folks who cannot afford live pigs, form pigs of dough, which they bake and offer in sacrifice" (II, 47).

In ancient Egypt and elsewhere pigs were kept by those who did not eat them except sacrificially. "The admission of swine into the fields, mentioned by Herodotus, should rather," wrote Wilkinson, "have been before than after they had sowed the land, since their habits would do little good for the farmer, and other animals would answer as well for 'treading in the grain'; but they may have been used before for clearing the fields of roots and weeds encouraged by the inundation; and this seems to be confirmed by the herd of pigs with water plants represented in the tombs" (34, ii, 18). Mr. Robert Henderson, the Galloway farmer, informs us that pigs were used in Scotland as in Egypt. "They may likewise," he said, "be allowed to go upon the new sown wheat, provided the ground is dry, as their tramping is of some service to that grain" (13, 36-7).

It was not because the pig was a rare animal in ancient Scotland, or because it was not domesticated, that a prejudice arose against the use of its flesh as food. Wild swine were numerous. As late as 1851 some remained. Mr. James Dickson, cattle dealer and author, states: "In the north of Scotland, and in some of the Highland districts, they have a small and half-wild kind of breed. . . . This breed is often seen running nearly wild" (8, 217). Mr. Robert Henderson mentioned several breeds in the Highlands and Lowlands, and he refers to those that "pick up seaweed and shell-fish." "Pigs," he writes, "are a kind of natural scavengers" and 'will feed on almost anything.' In miry and marshy ground

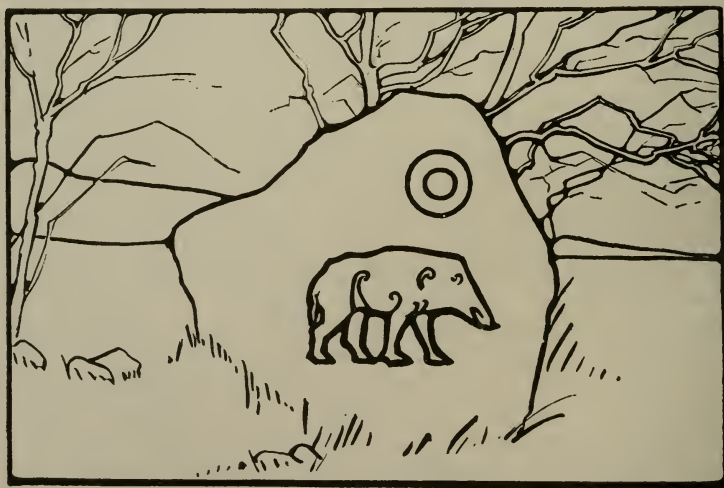
they devour worms, frogs, fern, rush and sedge roots," and so on. Some Highland swine were "very small, with long bristles upon their backs . . . flocks of swine are not now (1811) so numerous in the Highlands as formerly" (13, 14, 25, 41, 67).

As has been stated, pigs were kept at monasteries. David I of Scotland by a grant permitted the monks of Holyrood to cut wood in the royal forests of Stirling and Clackmannan and to pasture their swine in them. Scottish barons had "huge herds of swine" and ate pork freely (32, i, 233-6). The monks and barons, however, constituted a minority of the population. Many were of alien origin. The Norman barons especially were detested by the great majority of the inhabitants of Scotland. Before the Battle of the Standard two Norman barons, who had estates in Galloway, visited David I and protested against him leading "these savage tribes" against the Normans, "whose faithfulness in your defence has made them to be hated by the Scottish race." Saxon intruders were likewise unpopular. After the death of Malcolm Canmore, Donald Bane set himself "to expel from the country all the foreigners who had intruded into his dominions" (32, I, 243-4). Belgic and Dutch fishermen settled on the shores of the Firth of Forth, and in the burghs trade was chiefly in the hands of Flemings and of settlers from England. It is not surprising therefore to find that the minorities of intruders in Scotland kept pigs and cured and ate pork, and that Aberdeen, in which Flemish and English traders were prominent and influential ultimately became famous among Dutch shipowners for its excellent bacon and salted pork. An interesting reference to bacon is recorded in Pinkerton's History. In 1401 it was enacted by the Scottish Parliament "that if any unwholesome pork or bacon, or spoilt or foul salmon, was brought to market, it was to be seized by the bailies and sent immediately to the 'lipper folk' (lepers)." Evidently it was thought that the lepers, having contracted their disease from food, could not be further infected by foul salmon and unwholesome pork.

How then are we to account for the persisting prejudice against pork in Scotland? The Celts, the mediæval clergy, the Angles and Saxons, the Normans, the Vikings and the Flemings who settled in Scotland, reared swine and ate their flesh. There seems to be but one explanation. In Scotland, as in Finland, Northern Arcadia, Anatolia, Syria, Egypt and elsewhere, the prejudice against pork had origin before the birth of Christ. It has been perpetuated in Scotland by the descendants of the indigeneous peoples, the "common folk,"

who are still, as they formerly were, in the vast majority. In certain districts, as in the Hebrides, the descendants of pork-eating intruders have acquired the prejudice. James VI of Scotland and some contemporary lords had likewise succumbed to the ancient taboo.

Nothing persists like immemorial superstitions or like food prejudices based on superstitious beliefs. It is the common people who perpetuate old-world customs and still observe Halloween, May-day and other pre-Christian festivals, who visit "wishing wells" and make metal offerings and tie rags to "wishing trees." In the seventeenth century Dingwall Presbytery, as its minutes show (1656—1678) had to deal with offenders among the common people who perpetuated "heathenish practices" at Loch Maree, including the sacrificing of bulls, the pouring of oblations of milk on the hills, etc. Fairies, goblins, etc., are still believed in by sections of the inhabitants of Scotland. The pork taboo is only one of many survivals.



INVERNESS BOAR STONE.

That the pork taboo is of Eastern origin there can be little doubt. In Egypt the black pig acquired an evil reputation because it was a form assumed by Set, the slayer of Osiris. Set was the prototype of the Satanic pig demon. As Egyptian barley and Egyptian religious beliefs associated with the agricultural mode of life reached this country at a very early



period, so apparently did the Egyptian pig taboo. In Troy the star-spangled sow mother took the place of the star-spangled goddess-cow Hathor. The sow mother was also known in Crete where it was believed by one of the cults that Minos, or Zeus-Dionysus was suckled by a sow (the goddess), as Romulus and Remus were by the wolf, and other heroes were by the sheep, the deer, the cow, etc. "Wherefore," it has been recorded, "all the Cretans consider this animal (the sow) sacred, and will not taste of its flesh; and the men of Præsos perform sacred rites with the sow, making her the first offering at the sacrifice." Demeter had a sow as well as a mare form, and the pig-taboo of her cult has survived in Northern Arcadia. Professor Elliot Smith has discussed the connection of the pig with the Great Mother and clearly indicated why the animal acquired because of this connection an "unpleasant reputation" (30, 216—221).

It has to be recognised, however, that in Scotland, as in England, a different treatment of the pig obtained in certain areas. The white boar-god (in Egypt, Osiris), who was killed by the black boar (Set), figures in the legends regarding St. Kentigern and may be identical with the solar boar of the Inverness sculptured stone—a stone which does not have a single Christian symbol. This boar may have been the god of the Pictish "Orcs" (Young boars) who formed a military aristocracy of the Baltic amber traders of Celtic speech referred to by Tacitus, and of other peoples, including the ancient tribes of pre-Roman England whose warriors wore on their armour protective boar images (3, 87 and 135, 6), and those Scylding warriors who fought under a "boar's-head banner" (10, 110). The boar god was the son of the sow-goddess. Originally the boar was eaten once a year as in Egypt, and it may be that the prominence formerly given to the boar's head at the Christmas festival should be regarded as a relic of ancient sacrifice.

"The boar's head in hand bear I,  
Bedecked with bays and rosemary;  
And I pray you, my masters, be merry.  
*Quot estis in convivio,*  
*Caput apri deferō,*  
*Reddens laudes Domino,"*

is from a traditional carol sung at Queen's College, Oxford (27, 259). The cult which in Scotland has tabooed pork does not, however, appear to have been identical with the one which



had its boar's head feasts, but rather to have had something in common with that of the people regarding whom Lucian wrote (19, chap. 54): "Pigs alone, which they abominate, are neither sacrificed nor eaten"; the other cult may have been represented by those who regarded "swine without disgust but as holy animals." As has been indicated, the pork-detesting people of Scotland were represented both in the Lowlands and the Highlands. They were numerous enough and influential enough to perpetuate a very ancient taboo which survives as a prejudice till the present day.

## BIBLIOGRAPHY.

1. ANWYL, EDWARD. "Celtic Religion" (Religions: Ancient and Modern).
2. BONWICK. "The Ancient Irish."
3. "British Museum Guide to the Antiquities of the Early Iron Age."
4. BURT, CAPTAIN. "Letters from the North of Scotland." 1818 edition.
5. CÆSAR. "De Bello Gallico."
6. CASSIUS, DION. "Xiphilinus."
7. DALYELL, J. G. "The Darker Superstitions of Scotland." Edinburgh, 1834.
8. DICKSON, JAMES. "The Breeding and Economy of Live Stock." Edinburgh, 1851.
9. FRAZER, J. G. "The Golden Bough." Vol. ii, 2nd ed.
10. HALL, CLARK. "Beowulf in Modern English Prose."
11. HARRIS, RENDEL. "The Ascent of Olympus."
12. HENDERSON, G. "Survivals in Belief among the Celts."
13. HENDERSON, R. "A Treatise on the Breeding of Swine and Curing of Bacon." Leith (2nd edition), 1814. Preface dated 1811.
14. HULL, E. "Cuchullin Saga."
15. JOHNSON, SAMUEL. "A Journey to the Western Islands of Scotland in 1773." London and Glasgow ed., 1876.
16. JONSON, BEN. The Works of. Edited by W. Gifford, London, 1816.
17. *L'Anthropologie*, 1921.
18. LAWSON, J. G. "Modern Greek Folklore and Ancient Greek Religion."
19. LUCIAN. "De Dea Syria." (H. A. Strong's translation, London, 1913.)
20. MACGREGOR, ALEX. "Highland Superstitions."
21. O'CURRY. "Manners and Customs of the Ancient Irish."
22. RAMSAY. "Historical Geography of Asia Minor."
23. RAMSAY, DEAN. "Reminiscences of Scottish Life and Character."
24. RAY, JAMES. "History of the Rebellion in Scotland," by James Ray quoted in *Antiquarian Gleanings from Aberdeenshire Records*, Aberdeen, 1859.
25. *Revue Celtique*, vol. xiii.
26. RHYS, J. "Celtic Folk-lore, Welsh and Manx."
27. RICKERT, E. "Ancient English Carols."
28. "St. NINIAN and St. Kentigern, Lives of." Edinburgh, 1874.
29. SMITH, G. ELLIOTT. "The Ancient Egyptians."
30. SMITH, G. ELLIOTT. "The Evolution of the Dragon."
31. "Superstitions of the Scottish Highlands." Glasgow, 1900.
32. TYTLER, P. FRASER. "The History of Scotland." Edinburgh, 1864 ed.
33. WATSON, W. J. "The Picts: Their Original Position in Scotland." Inverness, 1921.
34. WILKINSON, J. G. "A Popular Account of the Ancient Egyptians." London, 1878 ed.
35. "Year Book of the Viking Society." London, 1912.

#### IV.—The Cultural Significance of the use of Stone.

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IF any element of culture be selected, and if inquiry be made throughout the world as to its presence or absence in different communities, it will usually be found, after a short study, that its distribution, at first seemingly capricious, is really according to definite rules. The formulation of these rules is the work of that branch of study which may be termed Human Geography, a study that lies on the borderland of Geography, Ethnology, Economics, and History. Why does any community possess any element of culture whatever? Why does a tribe make pottery, build stone houses, practice magic, or do any of the thousand and one things that are done by man? What is the history of any cultural element that is possessed by any community? Did that community invent the element independently of any other community, or did it borrow the idea? It is possible to conceive that, all the world over, communities have spontaneously invented arts and crafts, and in different ways. On the other hand it is possible that each art and craft was invented, once and for all, in one place, and at one time, and that every instance of the possession of that art or craft is the result of cultural transmission. It is not necessary to emphasize the tremendous intellectual gulf that lies between the standpoints of those who hold these opposite opinions. The whole theory of society depends upon the manner of origin of any particular art or crafts, or of any other element of culture. In view of the importance of this matter, I have chosen for discussion a cultural element that by its very simplicity seems to be capable of off-hand treatment without any exact study; in the hope of convincing the reader that it is wise to pause before venturing opinions on matters apparently so simple. I take the act of using stone for the building of monuments, for walls, and for any purpose of construction whatever. I shall leave on one side the use of stone for implements, although that is capable of treatment on exactly parallel lines.

*February, 1923.*

The question is :—Do men use stone spontaneously in any country because it is convenient for them to do so, or are they, when using stone, simply continuing a practice that has begun in some one place and has been propagated to other places? To study this question it is necessary to take into account, not merely prehistoric monuments, but also those made by existing communities. The making of megalithic monuments, for instance, has not yet died out: it is still proceeding in Melanesia, Assam, and elsewhere; and the study of the motives that lead men in these outlying places to erect these structures should serve to throw light upon the motives in the minds of early man in Britain and other parts of Europe. In India and Melanesia we can compare communities of identical stock who differ in their customs; so that one tribe has much stonework, while other tribes only use wood. To say that evidence from India and Melanesia is beside the point when dealing with the motives of early man in Europe is to beg the question. Men built megalithic monuments, and other stonework, for some reason or other; and it is necessary to discover that reason wherever possible, not to dogmatize from instances derived from one country, as is done so often. The practice of erecting megalithic monuments is widespread over the earth, and some cause must be assigned for the practical identity of structure shown in Ireland, Britain, France, Spain and Portugal, India, Syria, Melanesia, and so on. If the reason for this identity be discovered in some places it will probably serve to explain other instances.

The inquiry may well begin with the long barrows, dolmens, and stone circles that were erected in England and Wales and elsewhere, during the so-called "neolithic" and "bronze" ages. They constitute the first instances of the use of stone in the countries where they occur, and thus must play an important part in the discussion of the meaning of the use of stone. The current explanations of the distribution of these monuments can be divided into two parts. It is said that they are confined to high ground, because their builders were forced by the forests and marshes of the lowlands to avoid the lowlands. This assertion can be put on one side for future treatment, with the observation that the generalisation with regard to high ground is not strictly accurate. It is said, further, that megalithic monuments were built in places possessing supplies of suitable stone. It is to that assertion, made, tacitly or avowedly, by so many students, that attention must first be paid. In order to convince the reader that I am not wasting unnecessary time on this matter, I venture to

quote the words of Mr. O. G. S. Crawford, the Archæology Officer of the Ordnance Survey, whose appointment is a cause of so much gratification to those interested in the history of our country. Mr. Crawford, in describing, to the Royal Geographical Society, his future work on the Ordnance Survey, devotes a few words to Long Barrows. He says:—"A Long Barrow is a mound of earth, generally about 150 feet long, broader at one end, and covering the remains of bodies buried there in the Neolithic Age. In regions where stone was available, burial-chambers were built and the whole mound surrounded by a (generally rectangular) wall of dry masonry (2, 252). Mr. Crawford's inference is clear. Given a supply of stone a chamber is made: when stone is absent a chamber is not made. This must be put to the test.

In the first place it can be shown, without difficulty, that, in this, and every country, the available supplies of stone have had little to do with the practice of the use of stone. In England the megalithic monuments of the counties of Derbyshire, Yorkshire, and Lancashire, for instance, are confined to a few areas; in the neighbourhood of the carboniferous limestone in Derbyshire, round Whitby in Yorkshire, with a few long barrows on the Yorkshire Wolds. Hundreds of square miles of country are devoid of them. Where is the available stone for the purpose? A glance at a geological map will show that a vast area in these counties is occupied by the millstone grit formation, which is full of stone in every way suitable for the construction of megalithic monuments. I will offer to erect a monument far surpassing Stonehenge from great blocks of stone that lie within a mile or two of Pateley Bridge in Nidderdale. There are no megalithic monuments within dozens of miles of this place. The same can be said of any other part of this region. The great extent of the oolite formation in this country is but sparsely occupied by megalithic monuments. Again, although the granite formations of Dartmoor, Bodmin Moor, and the Land's End district are full of megaliths, there are none on St. Austell Moor, which is of granite. Why is that? If men built megaliths in the other places because they found granite, they should, on such a hypothesis, have built them on St. Austell Moor, but they did not. Vast stretches of this country, full of suitable stone, are bereft of megaliths. Again, is one to suppose that the only suitable stone for megaliths in Europe is to be found in Britain, France, Spain and Portugal, Denmark, Southern Sweden, North Germany, Italy, with a few scattered spots in Galicia and elsewhere? Are we asked to believe that the



whole of the rest of Europe contained no suitable stone, or that the climatic and other conditions were not suitable? Such an assertion is ludicrous. How about the Alps, the Rhine Valley, the valley of the Danube? How about the whole of the Balkans, which only contain a few dolmens near Adrianople? Obviously some selective factor in men's minds must have caused some stone-bearing areas to be settled rather than others. Certainly the presence of stone had, in itself, but little causative effect.

It is not necessary to show that vast areas of North America are, in like manner, entirely devoid of the use of stone, which is confined to the valleys of the Cumberland and Tennessee Rivers. The assertion that the use of stone was determined by its presence is still more insufficient, therefore, in North America. The general map of distribution of the use of stone throughout the world serves likewise to emphasize the fact that this practice has not arisen from the presence of suitable stone. The theory of a spontaneous origin of the practice must therefore be abandoned.

The builders of megalithic monuments had the habit of transporting large blocks of stone, often for great distances. The following quotation from the late J. R. Mortimer, who spent forty years in the excavation of mounds and barrows in the Yorkshire Wolds, will serve as a beginning. Speaking of the materials used in the construction of barrows, he says :

“ It was more the rule than the exception for clay, foreign to the spot, to be used in the erection of these barrows. It occasionally occurred in large quantities, and had sometimes been fetched from a considerable distance. I have also noticed, not infrequently, that clay, peaty matter, and sometimes fine loamy earth, brought from a distance, had been specially placed near the interment and the cinerary urn. Occasionally the interment rested on a few inches of clay, and infrequently a thin layer of the same material covered it. In Barrow No. 12 the grave in the chalk rock had a flooring of oolitic flagstones; while there were ten interments on a flooring of Liassic stones in Barrow No. 275; and in Nos. 61, C 38 and 281, were cists of the same foreign rock; while under the centre of Nos. 55 and 83 was concealed a broken or incomplete circle of large oolitic sandstone blocks (Calcareous Grit) enclosing interments.

“ The use of material from a distance in building these barrows seems to have been practised over wide areas. Canon Atkinson, when opening barrows on the Cleveland



moors, observed layers of white sand used in making the mound, which he considered was not obtainable within seven miles of the site of the barrows, and the greater part of another barrow was whinstone from a dyke three miles distant." (8, xxi-ii.)

Canon Greenwell remarks on a Barrow in Rudstone Parish in the East Riding :—

"The sandstone slabs, some of which showed by their peculiarly weathered surface that they had been taken from the sea-beach, could not have been obtained nearer than Filey Brigg, which is about twelve miles distant from the barrow. The transportation of these thence must have been a work of time and labour, especially to people who could have possessed nothing but the simplest appliances for effecting the carriage of weighty objects."

Canon Greenwell goes on to say that :—

". . . it seems strange in this case, where a deep grave had been sunk into the chalk, that it should have been considered necessary to undertake all the additional toil of constructing cists within the grave, when such constructions seemed in no way necessary for the protection of the interred bodies. I have seen in limestone districts something which may be considered more or less analogous; namely, that a hollow had been first made in the limestone rock, and then lined with slabs of sandstone" (4, 242-3).

These quotations demonstrate that the early users of stone in this country were not dependant upon local supplies, but were ready to transport large slabs over several miles of country. As Canon Greenwell says, no plausible reason can be assigned for the practice on the score of utility. It seems that they wished to use that particular sort of stone, and proceeded so to do regardless of trouble. We have high authority for concluding that some of the stones of Stonehenge itself, the blue stones, came from a great distance, perhaps from Brittany. That goes to show that the question of local supplies of stone really played but little part in the calculations of the early users of stone in this country. In other countries men have taken the trouble to transport stones, often of vast size, to places where they needed them. This is so, for instance in Brittany, where stones have been carried for twenty miles from a quarry in order to form part of a dolmen.

In India, Colonel Meadows Taylor mentions certain stones forming part of a tumulus at Shahpur, 13 miles north of Shorapur :—

“ These rocks, which are granite, were evidently brought from the Shahpur hills, a distance of three miles. There is no granite nearer—the geological formation changing from gneiss and laminar limestone nearly from the foot of those hills; and there are two deep nullas or rivulets, with scarped banks, between, which must have proved a great obstacle in rolling these masses, which is the only means by which I can conceive that they were moved ” (7, 347, 351).

The late Mr. Walhouse makes the following comments upon transportation of stones in India and elsewhere :—

“ The Coimbatore monuments are formed from the gneiss or granitic rock everywhere cropping out on the surface. I observed no instances of masses having been brought from a distance; but in the laterite district of Malabar, the covering stones of the sepulchral vaults (invariably granite) must frequently have been brought from lesser or greater distances. In the Central Provinces Col. Meadows Taylor describes masses exceeding 200 tons in weight that must have been moved from hills three miles distant.”

After mentioning transportation in England, he goes on to say that “ Smooth stones were observed by Mr. Atkinson to have been brought from distant rivers to tumuli on the steppes ” (13, 30), and Radloff states that many monuments on the banks of the Abakan have been transported many miles.

The vast region running eastwards from India to the other side of the Pacific was colonised by people from India, who have left monuments in certain places to testify to their presence. Ample evidence exists to show that these people habitually transported stone. In fact, their path across the Pacific can be traced in such a manner. A tale from Minahassa, in north-east Celebes, states that the colonisers of the country, who brought with them the use of stone and the practice of making rock-cut tombs, carried stones about with them. A man named Makarendé took a piece of the holy stone of a place called Kema, and planted it in the ground at another place called Kakas. Later on he disappeared into a tree, and while there he told his son to come and cultivate the land at Kakas. The latter did so, but was not successful until he obeyed the injunctions of his parent : “ You, my son, must

go to the east and fetch a piece of the stone that which I have planted in the ground, a heritage of your forefathers." These people of old have left stonework behind them in Central Celebes, in the shape of stone images, dolmens, and so forth. Some of these images are of a kind of stone not to be found in the neighbourhood, which makes it probable that, like the image in the other story, they have been transported from a previous home. This custom is well known in the island of Nias, west of Sumatra, noteworthy for its stonework. When a new village is to be made sacred stones are brought from the former site. This custom is doubtless responsible for the presence of a large stone of igneous formation on a coral island at Kei, just west of New Guinea (10, 46-8). It is used in ceremonial by folk that obviously came across the sea.

The most notable ruins of the Pacific are those of Micronesia. At Ponape in the Carolines, and at Kusaie and elsewhere, are remains of great works. At Ponape there was formerly an artificial Venice constructed of large blocks of stone. People who made such ruins must have had good reason for settling in such a place. It is said that the founders of Ponape came across the sea from Yap, an island many miles away to the west, floating on stones, and that they made the settlement of Ponape where the stones stranded on the reef. The people of Yap make much use of stone money, which they formerly got from the Pelews, three hundred miles away across the sea. Thus they actually had the custom of transportation of stones, and the tradition of Ponape rests upon some foundation of fact.

Elsewhere in the Pacific signs exist of the transportation of stones. This is so in Tongatabu, where it is known that large stones have been brought across the sea at some time in the past. The great trilithon is said by some to have been made of stones thus transported, but this is disputed. The most notable instance of transportation of stones is that of the region round Tahiti in the Eastern Pacific. The great pyramidal building, or *maræ*, at Opoa in Raiatea, an island in the neighbourhood of Tahiti, was the great meeting-place for the whole of the Eastern Pacific, to which came, at regular intervals, the chiefs from island groups thousands of miles distant, in their great canoes that carried 170 or more people, with banners flying, to join in festivities. It is said that, when a new *maræ* was made in any place, a stone was taken from the *maræ* of Opoa to form, as it were, the foundation stone of the new structure (9).

It is thus evident that the use of stone by people such as

the Polynesians and their ancestors does not depend upon local supplies of stone, but is a definite element of their culture. If no stone is present in a place where it is needed, then it is brought from a distance. More than that, the practice of transportation of stones from one settlement to another shows that religious and magical ideas were bound up with the use of stone, and it will be interesting to see the nature of these ideas.

The use of stone in the great region running east from India is mainly confined to three classes of structures: tombs, ceremonial enclosures, and stone circles. Sometimes, but rarely, houses, or house-foundations, are made of stone, but these can be put on one side for the present purpose. Stone is only used for houses in definite cultural circumstances that I have already discussed fully in another place. I wish to call attention to the stone circles.

Stone circles are far more widely distributed throughout India, Indonesia, and the Pacific than any other form of stone structure. They are invariably used as council-places, and for ceremonial purposes. The society with which they were connected is based on the clan system. Each state was composed of a number of clans, each connected with some sort of emblem, either animal, plant or material object, and each clan formed an autonomous unit that conducted its own affairs. Also, in some instances, where a definite ruling class existed, the heads of the various clans formed a council of the tribe or the state, presided over by a member of the royal family, who fulfilled the office corresponding to that of Vizier in ancient Egypt. Throughout the region of which I am speaking, in places where the custom of holding councils still persists, council meetings are held in stone circles, the members sitting on stones ranged in a circle. As has been said, in Nias, an island west of Sumatra, these stones are taken to the site of a new village, which is obviously in order that the sanctity of the old meeting-place may be transferred to the new. The custom of making stone circles for the purpose of council-meetings has persisted after that of erecting dolmens and pyramids has disappeared. That is because the clan council persists, even when a ruling class that used dolmen graves had disappeared. The clan council is one of the most persistent of elements of culture, and that well accounts for the survival of the stone circle.

Throughout this vast region, also, rulers, when engaged in council meetings, also sit on stone seats. This is a sign of



royal rank. This custom is associated directly with that of using stone circles for council-meetings.

In Europe it is well known that stone circles were used for council meetings. The ancient Danes are said to have elected their kings sitting on stones arranged in a circle. (5).

The evidence gained from places where stone circles are in active use, together with the traditional evidence derived from Europe, suggests that the stone circles of this and other countries were used for council meetings and other ceremonial purposes. That would well explain the positions of Avebury and Stonehenge. They would be the central meeting-places for the whole country. As I have already shown, this part of the country must have been thickly populated in the days when these great monuments were made (11).

In yet another way is it possible to show that the use of stone is an element of culture. For stonework has associations, in this country, with definite periods of civilisation. No stone was used for purposes of construction during the paleolithic age, yet it was lying on the ground. Those who assert that stone is used because it is available must explain why these early men did not use it. The obvious explanation is that they had not learned the practice: they were not yet civilised enough. But if it be argued that a certain level of culture must be reached before men come to use stone for monuments and so forth, it is evident that the real question is being evaded, namely, how has that level of culture been reached, and what, therefore, has really directed the minds of men towards the use of stone?

In this country the use of stone came in suddenly. For some reason or other men began to manipulate great blocks of stone, to make of them tombs, and, perhaps a little later, stone circles. No signs exist of previous attempts; on the contrary, the earliest monuments are usually the largest. The erection of megalithic monuments dies out after the appearance of the use of bronze in this country. Why was that?

The beginning of the end of the use of stone for tombs, stone circles, and so forth, began with the arrival in western Europe of small triangular daggers, in some places of bronze, in others of copper, of the use of solar symbols, of a great use of gold for ornaments, and, in places where megalithic monuments already existed, of tombs consisting of a beehive chamber of smallish stones, approached by a gallery, and surmounted by a tumulus of large size, usually made of earth. This civilisation also appeared in other parts of Europe, but the tombs were smaller. From that time onwards the use of



stone gradually disappears. The tumulus over the graves becomes smaller and smaller; it turns into a small mound of earth, and finally becomes a flat grave, the chamber having gone altogether.

It is fashionable to say that the coming of bronze was due to trade—that the small daggers and other bronze implements were bartered or hawked from one end of Europe to the other by men coming from the places of manufacture. That statement, I am convinced, is, generally speaking, a profound mistake, and it can only have been made when the evidence from the rest of the world is ignored. It is quite possible to imagine the bartering of the triangular bronze daggers, but it is impossible to barter a grave of the type that appeared in those days. It is also impossible to conceive how the solar symbols could have appeared in western Europe as the result of trade. It is patent, from the study of the sun-cult in other parts of the world, that any community in which the sun-cult is practised is ruled over by men calling themselves The Children of the Sun. When these Children of the Sun disappear, as they have done throughout Polynesia, for instance, usually because they were massacred or outlawed by their nobles, the sun-cult also disappears (9, Chapters 10, 11). The use of solar symbols is a sure sign of the existence of a sun-cult. No signs whatever exist in western Europe of such signs until the coming of bronze daggers. It is therefore possible, and indeed probable, that the real event that took place in those days was the spread, by way of Crete, of members of the Egyptian royal family, calling themselves Children of the Sun, who took with them the practice of making these great graves. These graves are, we are told, modelled on the pyramids of the Twelfth Dynasty in Egypt (6, 78). The use of the triangular bronze dagger appears in Crete with these new tombs. Such triangular daggers, but of copper, are figured on steles of First Dynasty mastabas in Egypt, the dagger being a sign for "chief" or "ruler." Since, throughout European pre-history, the wearing of swords, which developed out of the triangular dagger, was a mark of noble birth, it follows that the hypothesis of trade in bronze daggers at the beginning of the bronze age has nothing whatever to support it; all the evidence going to show that these daggers were the exclusive possession of a small group of men of royal birth. Traders would not have been able to get hold of them, even if such men existed in those days, which is doubtful.

Whatever explanation it is wished to put forward to

account for the coming of bronze to Europe, it is evident that the use of stone for purposes of construction suffers a decline, and in some places an eclipse. This degradation was continuous, so that, in Denmark for instance, and Southern Sweden, the use of stone for purposes of construction finally disappeared. For the Angles, Saxons and Jutes, who came thence to this country at the beginning of our era, made no use of stone whatever, either in their homeland or in this country. They built entirely of wood, and made ordinary graves in the ground such as we still make.

The failure of the Anglo-Saxons to use stone in this country is all the more remarkable in that they succeeded the Romans who, as is well known, were excellent stone-masons. But, curiously enough, the Anglo-Saxons avoided the Roman settlements, and made their homesteads sometimes miles away from the Roman highways. Only when missionaries came from Italy to convert the country did the use of stone begin again, and then only sporadically. The Normans, another branch of the same Scandinavian people, did not work stone when they came to this country. Their early castles were made of wood, and were set on the tops of earthen mounds. They were not the great structures of stone that are so well known to us as Norman castles.

In this country, therefore, the use of stone has more than once disappeared. It was unknown before the coming of people from the Mediterranean bringing with them the essentials of civilisation. After the arrival of bronze weapons the use of stone gradually disappeared, so that the mounds of the bronze age often have no stone in them at all. In the later times the use of stone suffers still further eclipse, until the arrival of the Romans, another people from the Mediterranean. Then came the Normans, another group from Scandinavia, who did not use stone. They were educated in the use of stone later on. Thus in all cases the use of stone in this country is associated directly with men coming from the Mediterranean. It is therefore legitimate to claim that this craft is really a cultural element, and that people do not use stone just because it happens to be the most suitable material in any particular circumstances.

Exactly the same story can be told in other parts of the earth. In Polynesia, America and elsewhere, the use of stone is mostly a thing of the past. In many places people who use wood or skin for their dwellings, and who make no use of stone, live in regions full of stone remains. It is well known what has happened in such places. The old civilisation has

been broken up, and the people have lost their rulers who needed such stone monuments for their tombs, or for their ritual performances. In Polynesia it is noteworthy that the later peoples who do not make stone monuments, such as the Maori of New Zealand, do not hold council meetings of the same nature as their ancestors in eastern Polynesia. In the old days the council was a potent force, and served to control the rulers. But when the old order broke up, the rulers became more autocratic, and the council became merely advisory, if it existed at all. The disappearance of stone in such places is thus the sign of profound social and political transformations, and is not a matter of caprice or accident.

The disappearance of the use of stone as the result of the appearance on the scene of more warlike communities is a phenomenon of world-wide extent. In Siberia the gold and copper miners of the valley of the Upper Yenesei erected thousands of megalithic monuments, especially near Minusinsk and in the valley of the Abakan, the stones along the Abakan often being carted for several miles to be placed in position. These old people practised irrigation, a noteworthy thing in a country where the average temperature is zero for the whole year. These people, sedentary miners, were succeeded by horse-riding nomads coming from the south, and bearing signs in their art of contact with the civilisations of Persia and Assyria. In these days the graves are much smaller. Finally, the Kirghiz, the descendants of these warriors, make still smaller stone graves (12).

A similar story can be told in Africa. In North-West and West Africa the first population made polished stone implements and erected megalithic graves, which are found from Algeria to the bend of the Niger. These were succeeded by warlike people from the south, who never used stone at all. In Palestine the same sequence is observable. The Israelites, tent-dwelling nomads, settled in a country possessing many dolmens, stone circles and other stonework.

In Europe it is evident that the solution of the problem must be along similar lines. In the old days in Scandinavia a council of great nobles served to check the rulers, who were usually sacred kings. The councils were associated with stone circles. But the Teutonic conquerors, such as the rulers of the Angles and Saxons, and those of other branches of the Teutonic ruling group, threw off the restraints of their home when they set out on their conquests, and the council disappeared. This is probably why the practice of using stone circles disappeared. A like solution can also be applied



in the case of the tombs. The later kings were bent on entirely different ends from those pursued by their ancestors. Men were being educated in the practice of war, and attention was given to plunder and to fighting, and not to the construction of elaborate tombs for the dead. In Europe, as elsewhere, what is known of the matter goes to show that the decay in the use of stone was due, not to natural, but to social causes. For some reason or other, certain communities gave up the use of stone, which only persisted continuously in the Mediterranean, and only appeared in Western Europe under the influence of the Eastern Mediterranean peoples.

It is possible, in Egypt, to watch the effect of social and political transformations on the use of stone. The Egyptian grave developed from the simple hollow scooped out in the sand, of early pre-dynastic days, to the massive pyramid of stone of the Fourth Dynasty, which marks the culminating point of the use of stone in that country. The earliest Egyptian tombs were of brick, and thus correspond to those of Sumer. But, in the early dynasties, the gradual deepening of the tomb finally caused the solid rock to be reached. One great difficulty that the Egyptian tomb-makers had to overcome was that of forming a satisfactory roof to the grave. But when they got down to the solid rock, in days after the copper chisel had been invented, it seems to have struck some bright genius that, if the tomb itself were cut out of the rock, this would solve the problem of roofing; so thus arose the custom of rock-cut tombs. In the early tombs with a rock-cut grave the superstructure was of brick. But eventually stone was used for the superstructure, probably as a direct result of the making of rock-cut tombs. It does not seem to have occurred to the Egyptians to use stone for the superstructures of their graves until they had actually begun to cut into the rock to make tombs. Then the idea seems to have come, and the kings thenceforth had stone worked for their tombs and temples. But the building of stone pyramids did not last indefinitely in Egypt. For from the Eleventh Dynasty onwards B.C. the pyramids degenerate in size and once again begin to be made of brick (1, 198). Thus in Egypt the construction of tombs began with brick and it ended with brick, with the exception of rock-cut tombs, which continued to be made during many centuries.

What is the cause of this gradual development and decline? It obviously has nothing to do with the supply of stone: for the stone was there all the time. It was simply a matter of the internal political condition of Egypt. In the times when



stone was being used for pyramids, during the Third and Fourth Dynasties, the kings of Egypt seem to have enjoyed undisputed power. The king's eldest son, the heir to the throne, acted as his vizier, and carried on the administration of the State. The governors of the provinces were chosen by the king. In this period the king was able to concentrate on the making of a vast tomb in which he should lie after death, a very ignoble aim, which shows what human beings will do when they have the chance. But, at the beginning of the Fifth Dynasty a change comes over the scene, and a gradual decline sets in that is like that which followed the arrival of the use of bronze in Western Europe. The Fifth Dynasty marks the coming to power of a new line of kings, calling themselves the Children of the Sun. These kings did not have the same power as their predecessors. They were forced, for some reason or other, to have for their viziers men whose names suggest that they were connected with the old regime. And from the beginning of the Fifth Dynasty till the end of the Sixth Dynasty, the office of vizier, formerly in the hands of the royal family, was filled by men of some other family. At the beginning of the Fifth Dynasty the governors of the provinces managed to secure power for themselves, and to make hereditary the succession to their offices. The kings of the Fifth and Sixth Dynasties were therefore faced with the necessity of keeping in order their vizier and their nobles: their power was not so undisputed as it was in the Third and Fourth Dynasties. Consequently the king was not able to command the labour necessary for the construction of immense pyramids. The nobles had to be placated and kept in order, if possible, and this absorbed much of the energies of the king. So the pyramids degenerated in size.

At the end of the Sixth Dynasty the ruling power collapsed, and the country was given over to anarchy and foreign invasion. So when the next dynasty that is known, the Eleventh Dynasty, appears in the light of history, the tombs are once again of brick. The old times when the king had complete control of the country never returned, and immense stone pyramids like those of the Third and Fourth Dynasties were never again made.

In Egypt, therefore, the use of stone is definitely dependent upon the conditions of the country. It is not a matter of caprice or of convenience. Evidently the idea to use stone only came when men were led, so to speak, right up to it. The steps by which the idea germinated can be watched, and they form a natural sequence in the circumstances. If, there-

fore, it took the most highly civilised nation of that time so many centuries to reach the idea of using stone, if also this practice was given up in later times, and reversion made to the use of mud-bricks, what warrant is there for believing that men, in other parts of the earth, have spontaneously come to use stone?

It may be claimed, as often happens, that the first use of stone was of unworked stone. Such an assertion begs the whole question at issue. It is certainly true that the pre-dynastic Egyptians sometimes used slabs of stone to support the walls of their tombs in the sand. They were also using all sorts of other substances for the same purposes. But the pro-dynastic Egyptians never made a stone structure that I know of. In countries such as England the first use of stone is in the form of definite structures, that obviously are built according to some plan. Only stone is used, and no signs exist of experimentation, as in Egypt. It is in these circumstances that I claim to assert that the first use of stone was that of unworked stone, is to beg the whole question, and to reduce the study of archæology to chaos. So long as such statements can be made unchallenged, there is but little hope of advance. It can be shown, in all parts of the world, that the earliest civilisations greatly excelled their successors in their command over the arts and crafts. It is practically invariably found that these early civilisations were characterised by the use of stone for purposes of construction, and that stone was worked in various ways, often as carved images. These advanced civilisations sent out influences to the surrounding countries, and it is found that, though the working of stone dies out, the use of stone sometimes continues, but unworked stone. I have already established this sequence in the East Indian Archipelago. It is equally clear in North America, in Polynesia, and in Africa. (*See* (7). There is thus no warrant for the statement as regards Europe. On the contrary, every use of unworked stone for monuments must be regarded as a case of culture-degradation. Now that the realisation of the truth of Elliot Smith's theory of the Egyptian origin of the Long Barrow and the Dolmen of Western Europe is being widely recognised (3, 5), it will soon be possible to approach the study of European pre-history in the proper manner. The Long Barrow, of unworked stone, is a degradation product of the Egyptian mastaba, which was of worked stone; the sequence therefore agrees with those of other parts of the world. Therefore it can be claimed, that the early civilisations of Western Europe were derived from

the Eastern Mediterranean, and eventually from Egypt, and by this way came the use of stone. This is the only explanation that fits the facts.

1. BREASTED, J. H. "A History of Egypt." 1919.
2. CRAWFORD, O. G. S. "Archæology and the Ordnance Survey." *Geogr. Jour.*, 59, No. 4, 1922.
3. CRAWFORD, O. G. S. The Long Barrows and Stone Circles in the Area covered by Sheet 8 of the  $\frac{1}{4}$ -inch Map (the Cotswolds and the Welsh Marches). Ordnance Survey. Professional Papers. New Series. No. 6. 1922.
4. GREENWELL, . "British Barrows."
5. *Journal of the Ethnological Society*, 1869.
6. LETHABY, W. R. "Architecture." Home University Library
7. MEADOWS TAYLOR. *Trans. Roy. Irish Acad.*, 24, 1873.
8. MORTIMER J. R. "Forty Years' Researches in British and Saxon Burial Mounds of East Yorkshire." 1905.
9. PERRY, W. J. *The Children of the Sun.* London, 1923.
10. — "The Megalithic Culture of Indonesia." Manchester, 1918.
11. — "The Problem of Megalithic Monuments and their distribution in England and Wales." *Manchester Memoirs*, 65, No. 13, 1921.
12. RADLOFF, W. "Aus Sibirien."
13. WALHOUSE. . "Notes on the Megalithic Monuments of the Coimbatore District, Madras." *Jour. Roy. Asiat. Soc.*, 1875.

# PROCEEDINGS

OF

## THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

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At a Meeting of the Council held on Tuesday, June 21st, 1921, the following were elected Student Associates of the Society :—

George Ernest Collins, B.Sc.Tech., 37, *Marshall Road, Levenshulme, Manchester.* John Stanley Herbert Davies, 58, *Parkfield Street, Whitworth Park, Manchester.* Laurence Barnett Timmis, B.Sc. Tech., A.I.C., 50, *Claremont Road, Moss Side, Manchester.* Stuart Henry John Wilson, B.Sc., *The University Union, Manchester.* Alice Graham Ikin, 39, *Kensington Avenue, Victoria Park, Manchester.*

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General Meeting, October 4th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

Mr. Coward thanked the Members of the Society for the honour they had accorded him in electing him President.

The following were elected Ordinary Members of the Society :

John Anderson, M.A., B.Sc., Ph.D., Research Chemist, The British Alizarine Co., Ltd., *Trafford Park, Manchester. 80, Bishop Street, Whalley Range, Manchester.* William Haywood Dawson, F.I.C., Manager, The British Alizarine Co., Ltd., *Trafford Park, Manchester. C/o The British Alizarine Co., Ltd., Trafford Park, Manchester.* Edwin Bayley, F.C.S., Works Manager, J. E. C. Lord (Manchester), Ltd., *Borough Road, Weaste, Manchester. C/o J. E. C. Lord (Manchester), Ltd., Borough Road, Weaste, Manchester.* David Brownlie, B.Sc., A.I.Mech.E., F.C.S., Technical Chemist and Engineer, Messrs. Brownlie and Green, Ltd., *Church Street, Cheetham, Manchester. 4, Grangethorpe Drive, Burnage, Manchester.* Margaret White Fishenden, D.Sc., *The College of Technology, Manchester. The College of Technology, Manchester.* R. H. Albery, M.Sc., Senior Physics Master, *Oldham Grammar School, Oldham. 464, Moss Lane East, Manchester.*

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Ordinary Meeting, October 4th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table. These included : *Tables of Refractive Indices*, vol. ii., *Oils, Fats and Waxes*, by R. Kanthack (8vo, London, 1921), pre-



sented by Messrs. Adam Hilger, Ltd.; *Transactions and Proceedings of the New Zealand Institute*, vol. lii, presented by Mr. Edward Melland; *Grammar of Colloquial Tibetan*, and *English-Tibetan Colloquial Dictionary*, by C. A. Bell (12mo, Calcutta, 1919 and 1920), presented by the Governor of Bengal in Council; *Œuvres Complètes de Christiaan Huygens*, T. XIII. (i. and ii.), T. XIV. (4to, La Haye, 1916 and 1920), published and presented by La Société Hollandaise des Sciences; and *Terrestrial Magnetism (British (Terra-Nova) Antarctic Expedition, 1910—1913)*, by C. Chree (4to, London, 1921), presented by the Captain Scott Memorial Fund.

The PRESIDENT delivered his Inaugural Address, entitled

### “The Preservation of our Fauna.”

This address is printed in the *Memoirs*.

Special Meeting, October 14th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

Dr. IRVING LANGMUIR, of the General Electric Company, Schenectady, N.Y., U.S.A., delivered an Address entitled

### “Molecular Structure.”

The modern conception of the atom is that of a nucleus surrounded by electrons, and all the chemical and physical properties of the atom are due, in a large measure, to the number of these electrons and the way in which they are arranged around the nucleus. Dr. Langmuir indicated three postulates, and explained in a number of cases how these postulates accorded with the simple and well-known properties of the atoms considered. He was able to show wherein lay the fundamental difference between organic chemical compounds and inorganic compounds; and he explained how the electrical conductivity of certain substances in the molten state or in solution could be accounted for, and why some elements are gaseous and others solid under ordinary conditions.

General Meeting, October 18th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The following were elected Ordinary Members of the Society :

William Anderson, B.Sc. (Glasgow), Lecturer in Physics, The College of Technology, Manchester. *Capstone, Mellor, Derbyshire*. Frederick Thomas Peirce, B.Sc. (Sydney), Physicist, The British Cotton Industry Research Association, Shirley Institute, East Didsbury, Manchester.

*The Shirley Institute, East Didsbury, Manchester.* Samuel Williams, Research Student in Botany. *The Botanical Department, The University, Manchester.* J. E. Jones, M.Sc., Lecturer in Mathematics in the Victoria University of Manchester. *The University, Manchester.* Harold Walkden, Research Worker on Plant Pathology, The University, Manchester. "*The Raft*," *Derbyshire Road, Sale, Cheshire.* Victor Ewart Stephens, A.R.Sc. (Dub.), A. I. C., Research Chemist, The British Alizarine Co., Ltd., Trafford Park, Manchester. *6, Willow Tree Road, Altrincham, Cheshire.* Marian E. Mitchell, B.Sc., Science Mistress, The High School for Girls, Manchester. *The High School for Girls, Manchester.*

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Ordinary Meeting, October 18th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Professor F. E. WEISS, D.Sc., F.R.S., exhibited various potato-tubers received from Mr. Moir, of Inverness, which illustrated both the results of grafting one kind of tuber upon another and also the results of hybridising.

Professor T. H. PEAR, M.A., B.Sc., read a paper entitled

**"The Visualization of Numbers in Space: Some Comments upon Galton's Theory of Number-Forms."**

This paper is printed in the *Memoirs*.

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At a Meeting of the Council held on Tuesday, October 18th, 1921, the following were elected Student Associates of the Society :—

Edith D. Johnson, M.Sc., Research Student in Botany, The Victoria University of Manchester. *37, Cavendish Road, Heaton Mersey.* Florence Brindley, M.Sc., Research Student in Botany, The Victoria University of Manchester. *483, Chester Road, Old Trafford, Manchester.* Elsie Dickinson, B.Sc., Research Student in Botany, The Victoria University of Manchester. *Ellerslie, Glossop.*

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General Meeting, November 1st, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The following lady, nominated by the Council, was elected a Corresponding Member of the Society :—

Mrs. C. W. Palmer, *27, Derby Road, Spondon, Derbyshire.*

The following were elected Ordinary Members of the Society :

Frederick Challenger, B.Sc. (London), Ph.D. (Göttingen), D.Sc. (Birmingham), F.I.C., Senior Lecturer in Organic Chemistry. *The University, Manchester.* Olive A. Wheeler, D.Sc. (London), M.Sc. (Wales), Lecturer in Education. *The University, Manchester.*

Ordinary Meeting, November 1st, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), followed by Mr. R. L. TAYLOR, F.C.S., F.I.C. (*Vice-President*), in the Chair.

The PRESIDENT referred sympathetically to the death of Mr. HERBERT PORTER, who had been an Ordinary Member of the Society since October 21st, 1919.

A vote of thanks was passed to the donors of the books upon the table.

Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., read a paper entitled :—

### **“Some Early Autographs of John Dalton.”**

The first Document is the marriage certificate of John Hudson, of Cockermouth, and Ann Fawcet, of Eaglesfield, of the people “caled Quakers,” on the 28th day of the first month “caled Janevary ” 1756. This is attested by Joseph Dalton, probably the father of John Dalton, and by other friends.

The second Document is the marriage certificate of William Alderson and Sarah Hudson, also of the “people called Quakers,” both of Eaglesfield, on the 4th day of the sixth month called June 1789. This is attested by John Dalton and Deborah Dalton. At this time John Dalton was 23 years of age, and it is evident that he signed both for himself and for his mother, Deborah Dalton.

In the list of other friends that have signed the document is the name of Isaac Fearon, who was probably related to Abigail Fearon, Dalton’s grandmother.

Professor Hickson also exhibited a very interesting book, entitled “The Schoolmaster’s Assistant, being a Compendium of Arithmetic,” published in 1774. This book must have been new when it came into John Dalton’s possession, for we see written on the blank sheets at the beginning and end of the book, “John Dalton’s Arithmetic Book, April 11th, 1775.” Although John Dalton was only 9 years old at this time there seems to be no doubt that these words are in his own handwriting.

Although the text of the book bears very few manuscript notes and figures, the covers and blank sheets are covered with what appear to be scribbles and flourishes. However, certain interesting things can be deciphered such as :—

“Henry Dalton begun to count 27 June 1803.

A. Dalton begun to write 8th day of June 1801.”

Henry was probably the son of another John Dalton also of Eaglesfield, whose relationship to the famous John Dalton Professor Hickson was not able to trace. He was born in 1793 and was therefore 9 years of age at that time. No record of A. Dalton was discovered.

At the end of the book there is the Lord's prayer written in such small writing that it can scarcely be read without a magnifying glass, and on the front page :—

“ Jane Dain mared Decr. 30th.”

“ J.D. Mared Dec. 30th 1777.”

Do these entries refer to an early romance in the life of John Dalton of which we have no other record?

Close to these two entries are the following four sums :—

1800	1841	1761	1777
1777	1777	16	1716
—	—	—	—
23	64	1777	61
16	—	—	—
—			
39			
—			

Whatever may have been the meaning of it, this figure or year 1777 seems to have been in his mind, as he wrote “ John Dalton's book 1777 ” twice on these leaves in addition to the inscriptions already mentioned.

A study of these autographs shows that in his boyhood he was inclined to the use of flourishes in his writing and that he practised the art of flourishes is shown by specimens of them on the first page. When he was 23 years of age these flourishes were somewhat reduced but were retained in a modified form in the capital “ D ” and in the “ n ” at the end of his surname.

The signature which was copied on the *Conversazione Programme* of 1919 was probably written in his old age, and in this the flourishes have disappeared.

Professor Hickson, on behalf of Mrs. S. J. Hickson and Mrs. L. H. Fletcher, presented the two marriage certificates and the arithmetic book to the Society.

Mr. R. W. JAMES, M.A., B.Sc., read a paper entitled :—

“ The Distribution of the Electrons in Atoms.”



When X-rays fall on an atom, it is supposed that each electron of the atom itself becomes a source of scattered X-radiation. The waves scattered by the electrons in the direction of the incident light will all be in phase, and the total amplitude scattered in this direction will be proportional to the number of scattering electrons. If the electrons in the atom lie at distances from the nucleus comparable with the wave-lengths of the X-rays, the waves scattered from the different electrons in any direction making an angle with that of the incident radiation will not be in phase, and the amplitude of the resultant wave will be correspondingly smaller. If we could measure the intensity of the radiation scattered in different directions by an atom, we could obtain the diffraction pattern for the atom and thus get an idea of the distribution of the electrons throughout its volume.

In the case of a crystal we are able to obtain some of the points on the diffraction curve due to the average distribution of electrons in a very large number of the atoms of which it is composed, by measuring the intensity of reflection of X-rays from its various planes. The necessary measurements have been made for the atoms of Chlorine and Sodium, using crystals of rock-salt. The method of making these measurements was described.

The results indicate that in the case of the radiation employed (the  $K_{\alpha}$  doublet of Rhodium) we are justified in assuming that each electron in the atom scatters independently. They show also that the atoms of sodium and chlorine have spherical symmetry, or that if the individual atoms have different properties in different directions, they are orientated at random in the crystal, so that the "average atom" has spherical symmetry. Distributions of electrons which will account for the observed curves are discussed. It is found for both atoms, that no arrangement in which the eight outer electrons all lie on a spherical shell at the same distance from the nucleus will give a curve of the type observed. The results suggest that on the average a few electrons, say three or four, lie in the region near the edge of the atom, and that the main concentration of electrons is much closer to the nucleus.

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#### Joint Meeting.

Joint Meeting of the Society, the Manchester Classical Association and the Textile Institute, November 4th, 1921, at the Textile Institute.

Professor J. OLIVER THOMSON, M.A., read a paper entitled :

**“Rome and China ; the Ancient Silk Trade.”**

Few articles of commerce have so romantic a record, with so many curious bearings on history and geography, as has silk. It is well known that the eggs of the Chinese mulberry silkworm were brought to Constantinople in the 6th century A.D., but that Chinese silk was known in the Roman world, as an import from China, and under a name derived from the Chinese, from the 1st century B.C. onwards. Although the idea of a spinning worm was familiar enough—(the native silkworm of Cos was known to Aristotle, and its produce was fashionable for a time in Rome, until ousted by the Chinese silk)—silk was long erroneously supposed to be a vegetable product, resembling cotton or “tree-wool,” an Indian product known to Herodotus in the 5th century B.C. The lecturer’s immediate subject was to show by what channels this silk reached the Roman Empire. The early history of silk in China was traced. China was generally regarded as a closed world, and so it was for long, but in the 2nd century B.C., owing to historical events which were traced, Chinese power spread westwards to the Pamir, and silk roads were opened to the west by way of Chinese Turkestan, on which much light has been thrown by the recent explorations and excavations of Sir Aurel Stein. The lecturer, after showing from the original Chinese notices this western expansion of the Chinese horizon, went on to deal with the eastern horizon of Greece and Rome, and to show how the two horizons advanced, so to speak, to meet each other and finally to overlap. Important data were given to the geographers, mariners and Ptolemy by a land journey made before 100 A.D. and prompted by the silk trade, by Stone Inver, a place west of Kashgar, to Sera, the Chinese capital or Si-an-fu. The sea trade of the Roman Empire also reached Ceylon early, and there were isolated efforts by merchants to find an outlet for silk on the sea frontier of China, probably at Hanvi in Tongking, which is the Gattigara of the Romans. This port, according to a remarkable Chinese notice, was visited by merchants posing as an Embassy from An-tun or Marcus Aurelius Antoninus in 166 A.D. Another important overlap of the Roman and Chinese horizons was at Ceylon, which was the usual goal of the Chinese merchants and was certainly visited by Chinese junks in the 6th century and probably earlier. Sections of the silk routes both by land and sea were long at the mercy of the Parthians, and later, of the Persians, and there were recurrent crises in the supply of silk

till in Justinian's time the eggs were brought to Europe—the central fact in the history of silk.

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General Meeting, November 15th, 1921.

Mr. R. L. TAYLOR, F.C.S., F.I.C. (*Vice-President*), in the Chair.

The following were elected Ordinary Members of the Society :

Arthur Pidd Greenhow, Merchant, *Field Side, Grange Road, Bowdon, Cheshire*. F. C. Thompson, B.Sc. (London), D.Met. (Sheffield), Professor of Metallurgy and Metallography. *The University, Manchester*. D. C. Henry, B.A. (Cambridge), Lecturer in Chemistry. *The University, Manchester*.

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Ordinary Meeting, November 15th, 1921.

Mr. R. L. TAYLOR, F.C.S., F.I.C. (*Vice-President*), in the Chair.

Mr. TAYLOR referred sympathetically to the death, on November 13th, of Professor A. SHERIDAN DELEPINE, M.B., C.M., M.Sc. Professor Delépine had been a Member of the Society for 27 years.

A vote of thanks was passed to the donors of the books upon the table.

Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S., read a paper entitled :—

**“On Certain Integrals occurring in the Kinetic Theory of Gases.”**

This paper is printed in the *Memoirs*.

Mr. J. E. JONES, M.Sc., read a paper entitled :—

**“The Dynamics of Collision of Diatomic Molecules.”**

Since Maxwell first propounded the Kinetic Theory of a Gas, considerable evidence has accumulated in support of his hypothesis that a gas, even in a steady state, consists of molecules in a continual state of agitation. By the application of the theory, it has been found possible to predict at least two important physical phenomena, which have subsequently been verified experimentally. All the work which has been done up to now has, however, been restricted to the case of a monatomic gas, that is, one in which the molecules possess perfect sym-

metry. It is highly desirable that the work should be extended to molecules of more complicated structure, but before any progress can be made, it is necessary to investigate the dynamics of collision of such molecules.

A theorem of general application to the collision of any two bodies is first established. It is found that there is a simple relation between the velocity with which the points of contact approach each other and the velocity with which they separate; in fact, their components resolved along the common normal are shown to be the same.

An application of this theorem to the case of diatomic molecules leads to a simpler method of finding their motion after a collision than has hitherto been used. It is found possible to deduce a simple relation between the impulse, acting on each body at collision, and the velocity of approach of the points of contact. Now the latter is known, since the motion before collision is supposed given, and hence the impulse on collision is easily calculated. The velocities after collision are then deduced from the ordinary dynamical equations of momentum, without the elaborate analysis which previous writers have indicated would be necessary.

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At a Meeting of the Council held on Tuesday, November 15th, 1921, the following were elected Student Associates of the Society:—

Dorothy Arning, M.A., Research Student in Physiology. *The University, Manchester.* Bessie Helena Edith Cadness, B.Sc., Research Student in Physiology. *The University, Manchester.*

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General Meeting, November 29th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (President), in the Chair.

The following gentlemen, nominated by the Council, were elected Honorary Members of the Society:—

Professor Horace Lamb, M.A., Sc.D., LL.D., F.R.S., lately Professor of Mathematics in the Victoria University of Manchester. *65, Grange Road, Cambridge.* Sir Ernest Rutherford, M.A., D.Sc., LL.D., F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge. *Newnham Cottage, Queen's Road, Cambridge.* Sir Arthur Schuster, Sc.D., Ph.D., LL.D., F.R.S., F.R.A.S., Honorary Professor of Physics in the Victoria University of Manchester. *Yeldall, Twyford, Berks.* Professor G. Elliot Smith, M.A., M.D., F.R.S., Professor of Anatomy in University College, London. *University of London, University College, Gower Street, London, W.C.1.*



The following gentleman was elected an Ordinary Member of the Society :—

Alan Sterling Parkes, B.A. (Cambridge), Post Graduate Student in the Victoria University of Manchester. *Parkfield, Werneth, Oldham.*

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Ordinary Meeting, November 29th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Mr. F. T. PEIRCE, B.Sc., Assoc.Inst.P., read a paper entitled :

### “Electromagnetic Valency and the Radiation Hypothesis.”

A magnetic doublet, consisting of two electrons in small orbits, ring or vortical electrons, furnishes a probable physical basis for a radiation hypothesis of chemical reactivity. It had been suggested by Dr. A. E. Oxley [*Proc. Roy. Soc., A.*, 98, 264] as an explanation of magnetic phenomena, and accords well with the chemistry of the elements and stereo-chemistry.

Its application to the phenomena of chemical dynamics suggests the following results for non-electrolytes :—

The bond can only be broken by radiation of definite frequency  $\nu$ , the most intense impact only resulting in ionisation. It can only be formed by an increment of molecular kinetic energy,  $h\nu$ , both processes following the law

$$k = se^{-h\nu} \frac{N}{R} \frac{1}{\theta}.$$

A criterion is provided for the observable effect of external illumination. This should be large for unimolecular decomposition or transformation, considerable or reversible reactions, especially the effect due to the radiation exciting the endothermic process, and inappreciable for irreversible combination. In all cases, the corresponding frequencies are selectively absorbed or emitted.

The energy change is double, corresponding to the attainment of the critical unstable equilibrium and of the normal stable state. The energy relation holds for the complete change in intrinsic energy  $U$ ,

$$-U = nH(\nu - \nu^1) \text{ per mol.}$$

The system is capable of accumulating absorbed radiant energy up to a limit of one quantum per electron. It emits in quanta, but absorbs and scatters continuously.

The bond is intensely rigid and local.

The frequencies and energy changes are altered by solvents but not by intermediate compounds.

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Ordinary Meeting, December 13th, 1921.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Miss LAURA E. START, M.Ed., read a paper entitled :—

**"Sea Dayak Fabrics and their Decoration."**

A part of the group of Iban cloths collected by Dr. A. C. Haddon, during the Cambridge Expedition to the East Indian Archipelago in 1899, was exhibited, and the method of pattern production as well as the symbolism of the patterns discussed by Miss Start.

The Iban excel in weaving, growing, preparing and dyeing the cotton they use. The warp is stretched in a frame, the parts of the web which are to remain undyed being protected by wrapping a bunch of the warp threads with a dried strip from a fibrous leaf, *Curculigo latifolia*. The process is repeated several times for multi-coloured designs.

The loom used for weaving is of the most primitive type. The web is looped over a warp beam which is attached to any two upright posts, the other end being looped over a breast beam to which a back strap is fastened. The woman sits on the floor with the back strap round her waist and thus manipulates the tension on the web. The raising of alternate groups of thread or threads is effected by

(a) a shed stick, and

(b) a "single" heddle.

A sword-shaped "beater-in" is generally used and a spool, often as long as the web is wide, carries the weft thread or threads.

Cloth woven in these looms generally has the warps in pairs—or threes—not doubled, and the weft is nearly always a double one or sometimes even 3 or 4 parallel threads form one pick. The result is a "poplin weave" in which the warp forms the surface. This of course gives the dyed warp pattern full effect.

Patterns are produced in other ways to a small extent, free spools similar to those used in Indo-China being adopted occasionally. Tribal badges are sometimes used at the back of the klambi or jacket, and are either worked in the brocade method

or a form of weft mosaic similar to that used by the Copts and the ancient Peruvians.

The patterns are traditional, being handed down from mother to daughter; they are symbolical and, in some cases, designate the rank or tribe of the wearer.

Anthropomorphs, zoomorphs and phyllomorphs form the chief motives and of these the animal patterns predominate.

The connection between the patterns and the myths of the Sea Dayak religion was explained, and the life-history of patterns, in which man, the frog, crocodile, shrew and tiger were used symbolically, shown.

The designs do not appear to have any affinity with those of the islands of Sumatra or Java or the Malay Peninsula, and for their origin we must therefore go back to the Proto-Malay stock from whom the Iban probably sprang, or consider the patterns a development due entirely to the Ibans themselves.

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#### Joint Meeting.

Joint Meeting of the Society and the Manchester Sections of the Society of Chemical Industry, The Institute of Chemistry and the Society of Dyers and Colourists, January 6th, 1922, at the Textile Institute.

Dr. EDWARD ARDERN, F.I.C. (*Chairman of the Manchester Section of the Society of Chemical Industry*), in the Chair.

Professor ARTHUR HARDEN, D.Sc., Ph.D., F.R.S., read a paper entitled :—

#### “ Bio-Chemical Method.”

The paper dealt with the methods which had been devised for Bio-Chemical research and the difficulties of obtaining reliable results owing to the manufactures which entered into experiments involving the living organisms.

The occurrence of vitamins in foodstuffs was especially mentioned and the differences between various kinds of vitamins was explained. The serious effects of ill-chosen diet for children were emphasized and attention was drawn to the destruction of vitamins by heat and especially by contact with air, whilst freezing had apparently a much less destructive effect.

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“ Young People’s ” Meeting, January 9th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The Second “ YOUNG PEOPLE’S ” Meeting of the Society was

held at 3-15 p.m. Short Illustrated Addresses were given by the President, on "Infant Birds"; and by Mr. John Allan, on "Soap Bubbles."

Mr. and Mrs. R. H. CLAYTON entertained the guests to tea, in the Common Room, at 4-0 p.m.

The PRESIDENT, in his Address on "Infant Birds," pointed out that, as a general rule, the young of birds which made elaborate nests hatch at an earlier stage than those which make little or no nest. The young are therefore more dependent upon parental care until they are able to fly. Ground nesting birds, as a rule, are clothed in thick down and can run and feed themselves immediately they leave the shell. He showed the great difference in the plumages of young birds and those of their parents, illustrating his remarks by photographs of the greenfinch, sparrow, lapwing, sheld-duck, herring- and black-headed gulls, nightjar, owls and cuckoo.

Mr. JOHN ALLAN explained the nature and demonstrated the formation of "Soap Bubbles." The skins of liquids, he said, were of different strengths: that of plain water is equivalent to a weight of about  $3\frac{1}{4}$  grains to the inch; that of a soap solution about one-third of this. Something like two million thicknesses of the black portion of a bubble which he blew and deposited on a ring would have to be placed upon each other to make a thickness of one inch. It is this skin upon water which enables such things as needles and pieces of tin to be floated upon it, and the lecturer demonstrated this by floating a flat piece of tin in a vessel of water, and propelling the tin along with a piece of camphor.

The effect of force upon liquids and bubbles, making them occupy the least possible space, was described by Mr. Allan; as also was the refraction of rays of light through a soap bubble, causing the various colours observed.

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#### General Meeting, January 10th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The following were elected Ordinary Members of the Society:

Harold Tunley, B.Sc. (London), Scientist, *The Manchester Grammar School, Manchester*. Gladys Clegg, M.Sc. (Liverpool), Research Assistant in Botany, *The Shirley Institute, East Didsbury, Manchester*. Kenneth M. Smith, A.R.C.S., Senior Lecturer in Agricultural Entomology, *The University, Manchester*. E. Holmes Smith, B.Sc. (Edinburgh), Senior Lecturer in Agricultural Botany, *The University, Manchester*.



Ordinary Meeting, January 10th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Mr. JAMES SMITH, M.A., read a paper entitled :—

**“Some Notes on Industrial Welfare, with Special Reference to Apprentice Training.”**

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General Meeting, January 24th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The following were elected Ordinary Members of the Society :

Dorothy Armstead, M.Sc (Vic.), Research Assistant in Botany. *The Shirley Institute, East Didsbury, Manchester.* William Bourke Wright, F.G.S., Mem. Roy. Irish Acad., District Geologist, Geological Survey. *Inglewood, Burlington Road, Altrincham.* Rufus Gaunt, M.Sc. (Leeds), Ph.D. (Berlin), Research Chemist. *47, Chapel Street, Salford.*

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Ordinary Meeting, January 24th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The PRESIDENT referred to the loss sustained by the Society in the death of Dr. Edward Hopkinson, M.P., on January 15th, 1922. Dr. Hopkinson had been a member since November 3rd, 1896.

A painting, on metal, representing a dray which belonged to Benjamin Joule, the father of James Prescott Joule, was exhibited by the PRESIDENT and then presented to the Society.

Mr. J. H. WOLFENDEN presented to the Society, through Mr. R. L. TAYLOR, a copy of “*The Hand-Book of Manchester*,” 2nd ed. (12mo., Manchester, 1842), by B. Love, a member of this Society.

Professor F. E. WEISS, D.Sc., F.R.S., made a short communication on the distribution of ancient stone monuments and copper mines in the Coniston district.

Mr. KENNETH M. SMITH, A.R.C.S., D.I.C., read a paper entitled :—

**“A Study of Some Little Known Sense-Organs in the Antennæ of Flies.”**

This paper contains a short account of some sense-organs situated in the antennæ of Diptera (two-winged flies). These sense-organs vary enormously in size, number and complexity,

from the simplest form in the mosquito to the most highly developed in the house-fly and that group of flies known as "Bee-Flies" (*Syrphidæ*). The structure of the organs is the same in fundamental design, though differing in detail, and consists primarily of a number of small processes or papillæ, almost protoplasmic in appearance, which are directly connected with highly sensory cells. A typical sense-organ may be described as follows:—A semi-circular cavity sunk below a "bottle-neck" closely guarded at the entrance against the ingress of foreign particles, by stiff bristles. On the floor of this cavity are situate the delicate papillæ above mentioned; up to the base of each papilla runs a sensory cell and the whole organ is embraced by a branch of the large antennary nerve.

The theories most commonly put forward in regard to the function of these sense pits are that they are olfactory or auditory, or are used in balancing. As regards the two latter views many workers have experimented—with a view to determining the function of the antenna as a whole—by cutting off, varnishing or mutilating the antenna in some way and then observing the behaviour of the fly. So far no very striking results have eventuated from these experiments.

It is now generally accepted by most entomologists that these sense-pits are olfactory and may serve for the dual perception—in the female of both food and the breeding place—in the male of food and the female.

The slides illustrating the lecture were drawings and photomicrographs of sections of the antennæ of various flies, the magnification being six hundred diameters in some cases and nine hundred and eighty in others.

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Ordinary Meeting, February 7th, 1922.

Mr. WILLIAM THOMSON, F.R.S.E., F.I.C. (*Vice-President*), in the Chair.

Dr. R. G. FARGHER and Dr. J. K. WOOD, F.I.C., were nominated auditors of the Society's accounts for the session 1921—1922.

A vote of thanks was passed to the donors of the books upon the table.

Dr. J. K. WOOD, F.I.C., read a paper, by himself and Mr. G. E. COLLINS, M.Sc.Tech., entitled:—

### "The Structure of Stannic Acids."

Some years ago experiments were commenced by one of the authors with the object of comparing the basic and acidic

strengths of various amphoteric metallic hydroxides. In continuation of this work the authors investigated the behaviour of stannic hydroxide under various conditions, and were thus led to make a study of the different modifications of stannic acid. Two lines of opinion regarding the nature of these compounds have been held by chemists. On the one hand, Engel, Kleinschmidt, and others have regarded  $\alpha$ - and  $\beta$ -stannic acids as compounds of definite composition, the latter compound having a molecular weight five times that of the former. Opposed to this view is that which has been held by Van Bemmelen, Vignon, Biron, Mecklenburgh, and others to the effect that the stannic acids form an uninterrupted series of substances of gradually increasing complexity, the substances becoming of more pronounced  $\beta$ -character the greater their degree of complexity. This difference in complexity and behaviour was ascribed by Mecklenburgh to variations in the size of the ultimate particles of the different modifications of stannic acid, but no explanation has been given as to why, under certain conditions, the size of the particles, and therefore the character of the acid, may suffer change. The authors, while accepting most of the views of the latter school of chemists, have endeavoured to explain the change of modification referred to above. They advance the hypothesis that the change of an  $\alpha$ -modification of stannic acid into the  $\beta$ -variety is to be traced to the amphoteric nature of stannic hydroxide, molecules of this substance, behaving as acid and base respectively, combining with each other to form products of gradually increasing complexity and partaking of the nature of salts. In the presence of a strong acid or a strong base, these salt-like complexes will suffer gradual decomposition, thus leading to a reversal of the  $\alpha$ — $\beta$  change. It was pointed out that this hypothesis gives a satisfactory explanation of why, under certain conditions of preparation, there should be a greater tendency for the formation of  $\beta$ - than of  $\alpha$  modifications of stannic acid, and it is also in harmony with the comparative behaviour of the two modifications as recorded in the literature and with that observed in the authors' own experiments. In conclusion, attention was drawn to the fact that this hypothesis may be applied to other substances besides stannic acid; the existence of different modifications of titanic acid, zirconic acid, etc., can be explained in this manner, and the behaviour of these substances, as found in experiments at present in progress, is quite in keeping with the requirements of the theory.

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Ordinary Meeting, February 21st, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the  
Chair.

A vote of thanks was passed to the donors of the books upon the table. These included Vol. 53 (1921) of the *Transactions and Proceedings of the New Zealand Institute*, presented by Mr. Edward Melland; and *Power*, October, 1921—, presented by Mr. C. E. Stromeyer.

Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., read papers entitled :

**I. "Estimation of the Smoke in the Atmosphere of Manchester, and Apparatus Used Therefor."**

The author found, by experimenting in the year 1913, that if a known volume of air were filtered through white filter or blotting paper, the smoke suspended in the atmosphere in an almost colloidal condition could be removed from it and remain fixed on the surface of the paper amongst the interstices of its fibres, leaving a stain more or less dark or jet black, according to the condition of the atmosphere at the time.

To study the conditions of the atmosphere as regards smoke at different times of the day and night he constructed a machine in a primitive form which answered the purpose; but as mechanical improvements suggested themselves new machines were made, till finally Mr. W. Gibson Rapp, of Birmingham, after two or three years of experiment, constructed one on more accurate mechanical lines. This was altered to a large extent by the author, and from the results of their combined experiences the fifth and final re-construction of the machine was made by Mr. Rapp. This now acts perfectly, and may be run night and day without stopping, furnishing records of the smoke every 15 minutes. It consists of three pumps submerged in mineral oil in a cylindrical vessel worked by a spindle which passes through a small electro-motor, the one end actuating the pumps and the other having attached to it a fan working in a 3-inch galvanised iron tube which brings the air from the outside and passes it in a continuous stream over the small box connected with the pumps, on the top of which is a hole  $\frac{1}{2}$  in.  $\times$   $\frac{1}{4}$  in., over which a ribbon of filter paper is passed and through which the air is sucked. Every 15 minutes the paper is drawn forwards half an inch by the action of the soft iron core of a solenoid magnet which is drawn into the coil when the current is switched on by a contact in the clockwork. This current simultaneously performs five different operations—(1) it lifts for one-sixteenth of an inch a weight of 10 lbs., which presses on the paper around the hole for the 15 minutes, during



which the air is pumped through it. (2) Another coil over the loose paper is converted into a magnet by the same current, when it attracts an armature which lies below the paper; these fix the paper between them. (3) The coil is then pushed backwards for half an inch, carrying the paper ribbon with it; (4) it pushes round a disc, which rolls up the paper with the impressions, on to a cylinder. (5) It breaks a short circuit which puts two glow lamps into the circuit to prevent the heavy sparking when the contact is broken by the clockwork. When this takes place the small coil ceases to be magnetic, its armature falls, and the coil and armature are carried backwards by a spiral spring which pulls out the core of the magnet from the coil ready for the next series of evolutions.

These daily records show that the air of Manchester is never absolutely free from smoke. It is cleanest between midnight and five or six o'clock in the morning, and foulest between nine and ten o'clock in the morning. There are on the average increased variations between one and two o'clock, between four and five o'clock, and between six and seven o'clock in the afternoon; then it gradually becomes less smoky up till midnight. It was shown that the smoke during the Coal Stoppage last summer was about one-tenth of what it became afterwards.

## 2. "Apparatus for Estimating the Chemical Impurities in the Air by Washing a Large Volume with a Small Quantity of Water."

This apparatus was designed after the Stromeyer appliance for washing small quantities of gas which by suction passes the gas in bubbles, together with the liquid, along a series of spirals in a glass tube, the liquid falling back into a small glass reservoir, to be used again and again as the gas is sucked away. The author used a 3 ft. tube,  $1\frac{1}{2}$  in. diameter, filled with small, pure snow-white silica pebbles. To the top of this tube was fixed air-tight, a  $\frac{1}{4}$  in. tube, 27 in. long, which was bent over downwards and fixed air-tight into the top of a vertical tube 8 in. long by  $1\frac{1}{2}$  in. diameter. Into the top of this tube, but just penetrating the cover, was fixed another tube attached to a mechanical pump worked by a dynamo, and from the bottom of this wide tube was fixed a narrow tube going to the bottom of the wide tube containing the pebbles. Into the bottom of the same cover was fixed the air tube, which was bent sharply round, and rose above the height of the tube containing the pebbles. Through this tube the air passed after being filtered through paper; it bubbled amongst the pebbles to the top, then washed up the narrow tube with some of the water to the top

reservoir, into which the water fell and passed from there down the pipe leading to the bottom of the tube containing the pebbles, to be used again. In this apparatus he washed 1,000 cubic feet of air in  $11\frac{1}{2}$  days.

This apparatus was made at first in glass, but he found the alkali in the glass prevented him from determining whether the air contained free mineral acid, so he re-constructed the apparatus in celluloid. The most remarkable results were that in using glass he obtained no free mineral acid but considerable quantities of combined chlorides and sulphates. When using celluloid he obtained free sulphuric acid and sulphates, but no trace of hydrochloric acid or chlorides. He left water in contact with celluloid for some weeks, and found no free acid had been dissolved from it; but on treating celluloid powder with boiling water he obtained both free sulphuric and nitric acid; so for further experiments the celluloid must be discarded and the apparatus constructed on a larger scale with silica tubes and provided with more powerful pumps. The pumps he used drew about 10 cubic feet of air per hour.

The machine used by Mr. Thomson for smoke estimation in the air was exhibited; also the apparatus for washing large volumes of air with small quantities of water, and both were shown at work.

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Ordinary Meeting, March 7th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Dr. W. M. TATTERSALL read a paper entitled :—

**“The sound-producing mechanisms of Crustacea.”**

The Manchester Museum has recently received two very interesting collections of Crustacea, one from the shallow waters and shores of East Africa and the other from Australia. There are one or two species new to science and several interesting records from the point of view of geographical distribution. Full details will appear in the final report. A number of the species collected exhibit mechanisms for the production of sound. Three main types of sound-producing mechanism are met with in Crustacea. (1) *Popping Type*. The sound is produced by the rapid withdrawal of a round peg from a socket into which it fits very tightly. The mechanism may be likened to the withdrawal of a cork from a bottle and the noise produced is very similar to that made by the pop of a cork. (2) *Fiddle*

*and Bow Type.* The fiddle portion generally takes the form of a row or series of rows of regularly arranged granules or tubercles or a file-like series of ridges. The bow portion is either a sharp smooth ridge or a row of granules. The rapid motion of the fiddle across the bow or *vice-versa* produces the sound. (3) *Plectrum Type.* The sound is produced by the friction or rubbing together of two series of stiff, modified, thickened and hollow spines. The first type is found in the snapping shrimps (*Alpheus*) so characteristic of the coral reefs of tropical countries. Examples of the second type are met with in the spiny lobster of our own coasts, several species of shore crabs from tropical waters like *Matuta*, *Platyonichus*, *Pseudozius* and the interesting amphibious crabs, *Ocyroda* and *Uca*, the denizens of tropical mud flats. The third type of sound-producing mechanism is found only in certain river crabs in Africa.

In all cases these stridulating organs are found in both sexes of a species. It is difficult to say what their function is, but in those instances where they have been most carefully studied—the crabs of the genus *Ocyroda*—there is evidence that the sound is produced as a warning-note to keep would-be intruders from entering a burrow already occupied.

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Ordinary Meeting, March 21st, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the  
Chair.

A critical account of

### “Wegener’s Theory of the Origin of Continents and Oceans”

was presented by Mr. W. B. WRIGHT, F.G.S., and Professor F. E. WEISS, D.Sc., F.R.S.

Mr. W. B. WRIGHT gave an introductory address outlining the main features of Wegener’s theory. This is merely a development of the modern theory of isostasy, which presumes an adequate degree of plasticity in the surface layers of the earth and the existence of a state of gravitational balance between its various parts. The lighter continental masses are assumed to be afloat on the heavier viscous basaltic substratum, and to be capable of lateral movement over it. The geological reconstructions thus rendered possible can be made to explain many geological and biological anomalies, which former theories have only dealt with in a clumsy and disconnected manner. A fairly successful attempt is made to show that if the reconstruction of

the geological past be made so as to explain one set of phenomena, many others fall naturally into line. Taking as a test case the two sides of the North Atlantic, supposed by Wegener to have lain in close proximity until a late geological date, Mr. Wright examined critically their geological history, and demonstrated the very close analogy in lithological aspect, fossil content, and tectonic movement that has obtained between these two regions from the earliest periods until their supposed separation in the Tertiary.

Professor F. E. WEISS said that it is a generally accepted fact that in Tertiary times the floras of North America and Europe were very similar and of a subtropical nature. Magnolias, Tulip-trees, Aralias, Swamp-cypresses, Sequoias now limited to America, were growing in Greenland and over the European Continent, so that Heer and Engler assumed that a northern circumpolar continent connected the Old and the New Worlds. But such a northern connection would not adequately account for the many American plants found in Southern Europe and also in Africa. To explain the occurrence of closely related species of many genera of flowering plants which occur in South Africa and America, it is necessary to assume a connection of these continents at all events in early Tertiary times. Wegener's theory, therefore, greatly facilitates the explanation of the presence of many American plants in the Old World in Miocene times. The close correspondence between the floras of the Cape and of Western Australia and the occurrence of certain allied genera and species in Australia and South America respectively is also easily explained by the union of these countries into an *Antarctis* up to Tertiary times.

The shifting of the poles, too, which seems to follow from the shifting of land masses, is a great help to the understanding of the changes in climate, which the nature of the fossil plants seems to demand. The absence of annual rings in the wood of the trees forming the coal measure forests indicates a climate similar to that of existing tropical forests, while the Cycads and their allies found in the Yorkshire Oolites and as far north as Spitzbergen, prove that at that period a semi-tropical climate must have reigned in those regions. A different position of the North Pole during the Great Ice Age would also explain why Siberia was not glaciated at that time, as it cannot have been, for it was from Northern Asia that the new vegetation spread into Northern and Central Europe after the last glacial period. There is no doubt, therefore, that we can more readily explain the facts of the present and past distribution of plants by



accepting Wegener's theory of the origin of continents than by any other hypothesis.

General Meeting, April 4th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.S.S. (*President*), in the  
the Chair.

The following gentlemen were elected Ordinary Members of the Society :—

Robert Bruce Harley, B.Sc. (St. Andrews), A.I.C., Research Chemist. *The British Alizarine Co., Ltd., Trafford Park, Manchester.* Rupert William Palmer, M.C., M.Sc., F.G.S., Senior Lecturer in Geology and Palæontology. *The University, Manchester.* George Ernest Collins, M.Sc.Tech., A.I.C., F.C.S., Physical and Colloid Chemist. *37, Marshall Road, Levenshulme, Manchester.* Ernest Clark, B.Sc., Vice-Principal of The Royal Technical College, Salford, and Chief Lecturer in Chemistry. *The Royal Technical College, Salford.* Cecil J. T. Cronsshaw, Works Manager. *The British Dyestuffs Corporation (Blackley), Ltd., Blackley, Manchester.* William Granville Pemberton, Chemist. *60, Delamere Avenue, Pendleton, Manchester.* Francis Philip Slater, Physicist to The Fine Cotton Spinners' & Doublers' Association, Ltd. *Rock Bank, Bollington, near Macclesfield.*

Ordinary Meeting, April 4th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), followed  
by Mr. W. HENRY TODD (*Vice-President*), in the Chair.

The PRESIDENT exhibited a Smelt, *Osmerus eperlanus*, which he picked up at Rostherne Mere on March 31st. These anadromous fish have been land-locked in the mere for at least 200 years, as described in a short paper on the subject read before the Society on May 7th, 1912.

Miss WINIFRED M. CROMPTON, M.A., made the following short communication :—

An ancient Egyptian flax bat for beating the flax stems, a wooden flax stripper for removing the seed capsules, and some samples of ancient Egyptian linen, all from the Manchester Museum, were shown by Miss W. M. Crompton. She explained that an examination of these cloths had been made by the late Mr. W. W. Midgley, of Bolton, and his report published in Petrie, "Heliopolis, Kafr Ammr and Shurafa," proved that the fibres were in the majority of cases finer than the finest quality of the present day, clearly showing that retting, heckling and carding were well understood. In one sample exhibited the measurements were :—

Average diameter of 10 fibres in warp=2173 to an inch.

" " " " weft=1925 "

Fibre of minimum diameter =5000 "

(The present finest Irish linen,—average 1818, minimum 2857). Another sample, not in Manchester, contained fibres equalling 6666 to an inch. The samples dated to 3300 B.C.

Mr. E. HOLMES SMITH, B.Sc., read a paper entitled :—

**“Retting, and the production of Fibre Flax in Belgium and elsewhere.”**

This paper dealt with the history and origin of cultivated flax. It was shown that the fibre flax plant cultivated to-day is the very same as was cultivated 3,000—5,000 years ago by the ancient Egyptians. It was introduced into the north of Europe by the Finns, and afterwards into the rest of Europe by the Western Aryans and Phœnicians about 2500—1200 B.C. It was introduced into Britain by the Romans. The difficulties in the way of successful cultivation were pointed out and the technical processes of “retting” and “scutching” were briefly described.

A series of slides showing the cultivation, method of “retting” and preparing of the world’s finest flax fibre in Belgium were shown, also the methods adopted in Ireland and Russia. Specimens of all the principal commercial flax fibres were shown with pre-war and present-day values attached.

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Annual General Meeting, April 25th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved :—“That the Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society’s *Proceedings*.”

A vote of thanks to the retiring officers and other members of Council was passed unanimously. The following members were elected officers of the Society and members of the Council for the ensuing year :—

*President* : T. A. COWARD, M.Sc., F.Z.S., F.E.S.

*Vice-Presidents* : Sir HENRY A. MIERS, M.A., D.Sc., F.R.S.; W. HENRY TODD; ARTHUR LAPWORTH, D.Sc., I.L.D., F.R.S., F.I.C.; C. E. STROMEYER, O.B.E., M.Inst.C.E.

*Secretaries* : H. F. COWARD, D.Sc., F.I.C.; T. H. PEAR, M.A., B.Sc.

*Treasurer* : R. H. CLAYTON, B.Sc.

*Librarians* : C. L. BARNES, M.A.; WILFRID ROBINSON, D.Sc.

*Curator* : W. W. HALDANE GEE, B.Sc., M.Sc.Tech.

*Other Members of the Council* : W. M. TATTERSALL, D.Sc.; F. E. WEISS, D.Sc., F.R.S., F.L.S.; FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.; LAURA START, M.Ed.; SYDNEY CHAPMAN, M.A., D.Sc., F.R.S.; W. L. BRAGG, M.A., F.R.S.; The Rev. A. I. CORTIE, S.J., F.R.A.S., F.Inst.P.; R. L. TAYLOR, F.C.S., F.I.C.; WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.

*Ex Officio* : The CHAIRMAN and the SECRETARY of the Chemical Section.

Ordinary Meeting, April 25th, 1922.

A vote of thanks was passed to the donors of the books upon the table.

Mr. W. J. PERRY, B.A., read a paper entitled :—

**“On the Cultural Significance of the Use of Stone.”**

This paper is printed in the *Memoirs*.

Special Meeting, May 2nd, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

Sir WILLIAM BOYD DAWKINS, M.A., D.Sc., F.R.S., read a paper entitled :—

**“The Crust of the Earth.”**

In view of the recent discussion in the Society and in the Press relating to the crust of the earth, it is desirable to define the current theory held by the leading geologists for the last sixty years. The theory is founded on the researches of eminent mathematicians, chemists and physicists such as Helmholtz, Kelvin, Hopkins, Bishoff, and Durocher, and has been accepted by zoologists and botanists—Huxley, Darwin, Wallace, Sclater, as an adequate explanation of the distribution of plants and animals, not only on the present surface of the earth, but also in the remote past revealed in the geological record.

The crust of the earth is that portion of the solid rock that is open to observation. It is of unknown and probably varying thickness, and very thin as compared with the 3962.5 miles of the earth's radius. It is continuous under both sea and land.

It is composed of rocks arranged in the following downward order :—

- (1) Igneous crystalline ; or which have formerly been molten rock.
- (2) Metamorphic ; or rocks altered by heat and pressure.
- (3) Fragmental ; mostly accumulated under the sea.

The last consists of two well defined groups, the Acid Siliceous such as the granite, and the Basic or Basaltic, such as the Gabbros, differing in their chemistry, and being related to one another as oil is to water. It is therefore probable that the first crust formed on the cooling earth belonged to the siliceous group, and that the basic solidified at a later time. Durocher points out that both these groups are derived from two distinct magmas or zones of highly heated matter, which if cooled slowly under high pressure and in presence of water, take the largely crystalline structure of granite and gabbro, and other Plutonic rocks, while if, as in the volcanic rock that cool swiftly under less pressure, they are micro-crystalline or vitreous.

We will now consider the evidence of density as to the structure of the earth below the crust.

The density of the crust is	...	...	2.5
„ Siliceous rocks	...	...	2.4—2.7
„ Basic	...	...	2.8—3.7
„ The earth	...	...	5.5—5.6

This high density of the earth may be accounted for by the presence of the heavy elements, and more particularly of the heavy metals in the central parts such as iron, gold, platinum, iridium, etc. It may be explained by the view that the earth consists of a metallic centre surrounded by heavy bases arranged according to their density in a series of zones ending in the crust.

I now turn to the evidence of temperature as to structure. The volcanoes and hot springs prove that there is great local heat at great depths below the surface, and the experience of miners everywhere establishes the increase of heat as the depth increases, the variation being due to the varying conductivity of the rock. If we follow Snell in taking the average increase in Europe to be one degree rise for 65 feet of depth, the temperature at a depth of 34 miles will be no less than 2786 degrees Fahr., sufficient to melt most of the elements. Hence the idea that the crust is floating on a molten ocean. But if the heat at great depths is enormous so is the pressure which raises the melting point—as is well known in steel works. If the temperature once masters the pressure there will be fluidity. If the pressure preponderates, there will be solidity. As the relation of heat to pressure at great depths is unknown we cannot be certain whether the crust is based on fluid or solid zones of the two magmas.

According to Lord Kelvin the earth as a whole is an elastic solid like an equal sphere of glass or steel, while Hopkins takes it to be solid to a depth of 800 to 1,000 miles from the surface. In my opinion it is probably a solid with fluid areas of molten rock where the temperature is high enough to overcome the pressure.

The crust follows the contraction of the cooling earth, and as it has to occupy a smaller space is subjected to enormous lateral pressure which is indicated by the folds and the faults. The latter divide the rocks into wedges, one series with their bases downwards and the other with their bases upwards. The movement as a whole is vertical, the greatest lateral displacement on record being between 5 and 6 miles in the Highlands of Scotland. The existing land is an area of elevation, and the



seas are areas of depression, but the fact that the stratified rocks forming the land have been formed mainly under the sea, and that the characteristic contours of the land, due to subaerial agents of attack—hills, ravines, valleys—occupy the floor of the sea (down to at least 1,000 fathoms in the case of the submerged canyon of the Congo), prove that land and sea have changed places.

The distribution of plants and animals in the geological record proves this to have been the case. The British Isles were a portion of the Continent in the Pleistocene Age and have assumed their form from depressions beneath sea-level. They were continental also in the Pliocene Age. In the Miocene and Eocene Ages they were linked with North America by a tract of forest-covered land extending from the Orkneys to Iceland and Greenland, now dividing the depths of the North Atlantic from the Arctic Ocean.

This theory of the earth's crust holds the field at the present time. It is not shaken by Dr. Wegener's speculation, because the latter is founded upon assumptions negatived by the facts, that the crust is discontinuous, that the existing land masses have split off and floated away from one another on a basaltic magma more or less fluid, along with their fauna and flora, and that the lands on both sides of the Atlantic fit into each other like the pieces of a jig-saw puzzle, and originally formed parts of a primordial continent.

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General Meeting, May 9th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

The following gentlemen were elected Ordinary Members of the Society :—

Percy G. Jackson, F.I.C., Analytical and Consulting Chemist. *13, St. Clement's Road, Chorlton-cum-Hardy, Manchester.* George Alfred Rea Foster, B.A. (Cambridge), Research Physicist. *The Shirley Institute, East Didsbury, Manchester.* James Peter Andrews, B.Sc. (London), Research Physicist. *The Shirley Institute, East Didsbury, Manchester.* Albert Edward Owen, B.Sc. (London), Research Physicist. *The Shirley Institute, East Didsbury, Manchester.*

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Ordinary Meeting, May 9th, 1922.

Mr. T. A. COWARD, M.Sc., F.Z.S., F.E.S. (*President*), in the Chair.

Mr. DONALD A. MACKENZIE read a paper entitled :—

**"The Scottish Pork Taboo."**

This paper is printed in full in the *Memoirs*.

PROCEEDINGS  
OF  
THE MANCHESTER LITERARY AND  
PHILOSOPHICAL SOCIETY.

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*CHEMICAL SECTION.*

Ordinary Meeting, November 11th, 1921.

Mr. J. H. LESTER, M.Sc., F.I.C. (*Vice-Chairman*), followed by  
Dr. H. F. COWARD, in the Chair.

Mr. LEONARD E. VLIES, F.C.S., F.I.C., having, on account of  
ill-health, resigned the Chairmanship of the Section, Dr. H. F.  
COWARD, F.I.C., was elected CHAIRMAN for the Session 1921-22.

Mr. R. H. CLAYTON, B.Sc., gave a resumé of the recent  
Canadian Meeting of The Society of Chemical Industry.

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Ordinary Meeting, November 25th, 1921.

Mr. J. H. LESTER, M.Sc., F.I.C. (*Vice-Chairman*), followed by  
Dr. H. F. COWARD, in the Chair.

L. GUY RADCLIFFE, M.Sc.Tech., F.I.C., introduced a discussion  
on

**"The Sludging of hydrocarbon oils."**

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Ordinary Meeting, December 9th, 1921.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.

Dr. MARGARET FISHENDEN opened a discussion on

**"The Development and Design of the Domestic Grate."**

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Section Soirée, January 13th, 1922.

By invitation of the Chairman and Committee, a Section  
Soirée was held at 7-0 p.m.

Mr. JOHN ALLAN gave a demonstration of

**"Soap Bubbles."**

Mr. R. H. CLAYTON gave an illustrated resumé of  
"The Canadian Tour of the Society of Chemical  
Industry."

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Ordinary Meeting, January 27th, 1922.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.  
The CHAIRMAN opened a discussion on  
"The Performance of a Centifuge."

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Ordinary Meeting, February 24th, 1922.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.  
Professor F. C. THOMPSON, B.Sc., D.Met., opened a discussion  
on :—

"The Electrical and Magnetic Properties of Steel."

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Ordinary Meeting, March 31st, 1922.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.  
Mr. ARTHUR GROUNDS, B.Sc., A.I.C., A.M.I.Min.E., opened a  
discussion on :—

"Briquetting of Coal and other substances."

Mr. Grounds dealt with the manufacture of coal briquettes from small coal, including the utilisation of what had previously been regarded as waste coal. The work of the Lignite Utilisation Board of Canada was outlined and it was shown how Canada could, by successful treatment of the large deposits of lignite occurring in the Western regions, become independent of the American supplies of anthracite which have at present to be imported. The production of smokeless fuels of the "Carbocoal" type, and the briquetting of coals by pressure alone, a process in which no binding medium is added, were described.

The briquettes are of excellent appearance and are stronger than the large coal of the same class. The manufacture of lime-sand bricks, and of clinker bricks from refuse destructor clinker was dealt with, together with the utilisation of blast furnace slag for the manufacture of building blocks.

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Ordinary Meeting, April 28th, 1922.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.  
Mr. J. R. HANNAY, F.I.C., introduced a discussion on  
"The Steaming Process in Calico Printing."

Annual General Meeting, May 5th, 1922.

Dr. H. F. COWARD, F.I.C. (*Chairman*), in the Chair.

The following members were elected Officers of the Section and members of the Committee for the ensuing year :—

*Chairman* : LEONARD E. VLIES, F.C.S., F.I.C.

*Vice-Chairman* : H. F. COWARD, D.Sc., F.I.C.

*Hon. Secretary* : D. M. PAUL, B.Sc., A.I.C.

*Other members of the Committee* : W. H. BENTLEY, D.Sc., F.C.S.; R. H. CLAYTON, B.Sc.; HAROLD MOORE, M.Sc.Tech., F.C.S., A.I.C.; RONA ROBINSON, M.Sc., A.I.C.; DAVID BAIN, D.Sc.; DAVID CARDWELL, M.Sc., F.I.C.; J. A. R. HENDERSON, D.Sc., F.C.S.; F. C. THOMPSON, B.Sc., D.Met.; J. C. WITHERS, Ph.D., A.I.C.

The Ordinary Meeting of the Section arranged for this date was postponed.



MANCHESTER  
LITERARY AND PHILOSOPHICAL SOCIETY.

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*Annual Report of the Council, April, 1922.*

*Membership.*

The Society had at the beginning of the Session an ordinary membership of 343. Since then 28 new members have joined the Society. Twenty-six members have resigned, nine have been removed from the list, one has been elected an honorary member, and three members (Professor A. SHERIDAN DELEPINE, M.B., C.M., M.Sc., Dr. EDWARD HOPKINSON, M.A., M.P., M.Inst.C.E., and Mr. HERBERT PORTER) have died. There are, accordingly, at the end of the session 332 ordinary members of the Society.

The Society has lost by death three honorary members (Mr. J. G. BAKER, F.R.S., L.L.S., Dr. JULIUS ELSTER and Professor LEO KOENIGSBERGER, Ph.D.), and one (Professor MAX FURBRINGER) resigned. On the nomination of the Council, four new honorary members (Professor HORACE LAMB, M.A., Sc.D., LL.D., F.R.S., Sir ERNEST RUTHERFORD, M.A., D.Sc., LL.D., F.R.S., Sir ARTHUR SCHUSTER, Sc.D., Ph.D., LL.D., F.R.S., and Professor G. ELLIOT SMITH, M.A., M.D., Litt.D., F.R.C.P., F.R.S.) have been elected, making a total of 34 honorary members at the end of the session. Mrs. C. W. PALMER has been elected a corresponding member of the Society.

*Student Associates.*

Under the regulations governing the admission of Student Associates, which came into force at the beginning of the Session 1921-22, the Council has admitted ten Student Associates.

*Meetings, 1921-22.*

Eighteen papers have been read at the Society's ordinary meetings during the year; nine shorter communications have also been made. In addition, eight meetings and a Soirée have been held by the Chemical Section.

The second "Young People's Meeting" was held on January 9th, the audience being even larger than that present at the first meeting in January, 1921. Short illustrated addresses were

given by the President and Mr. John Allan, and Mr. and Mrs. R. H. Clayton entertained the guests to tea in the Common Room.

At a Special Meeting, held on October 14th, Dr. Irving Langmuir gave an address on "*Molecular Structure*." Two Joint Meetings were also held: the first with the Manchester Classical Association and the Textile Institution, at which Professor J. Oliver Thomson gave an address on "*Rome and China: the Ancient Silk Trade*"; the other, with the Manchester Sections of the Society of Chemical Industry, the Institute of Chemistry, and the Society of Dyers and Colourists, at which Professor Arthur Harden read a paper entitled "*Bio-Chemical Method*." The two Joint Meetings were held at the Textile Institute.

The times of the ordinary meetings were altered to 5-30 p.m. and 6-30 p.m. alternately.

The Hon. Sir Charles A. Parsons, K.C.B., M.A., D.Sc., F.R.S., has consented to deliver the second *Joule Memorial Lecture* early next Session.

#### *Society's Accounts.*

The cash account of the Society and a statement of assets and liabilities are appended to this report.

The latter statement shows a small improvement in the financial position of the Society in comparison with the previous year.

#### *Officers and Members of Council.*

On April 12, 1921, the following resolution of the Council was approved by the Society:—

"That the Council be constituted as follows: a President, four Vice-Presidents, two Secretaries, a Treasurer, two Librarians, a Curator and nine other ordinary members."

By a resolution, approved by the Society on October 28th, 1919, the Chairman and Secretary of the Chemical Section are members *ex officio*.

#### *Society's Library.*

The Librarians report that during the Session 342 volumes have been stamped, catalogued and press-marked; 311 of these were serials. The total number of volumes catalogued to date is 39,482.

The additions to the library for the Session amounted to 769 volumes: 705 serials, and 64 separate works. The donations

(exclusive of the usual exchanges) were 46 volumes; 2 volumes were purchased in addition to those regularly subscribed for. During the year 89 volumes have been bound in 73 covers. In the previous Session the corresponding numbers were 87 volumes in 72 covers.

The donations to the Society's Library during the Session included gifts of books by Messrs. Edward Bennis and Co., Ltd.; Mr. David Brownlie; Mr. Edward Melland; Mr. C. E. Stromeyer; Mr. J. H. Wolfenden; Mr. H. J. Woodall; Messrs. Adam Hilger, Ltd.; the Committee for the Publication of the Scientific Results of the Captain Scott Antarctic Fund; the Trustees of the British Museum (Natural History); the Royal Geographical Society, London; the Geological Society, London; the Patent Office Library, London; the Director of the Royal Observatory, Greenwich; the Meteorological Office, London; the Director of the Geological Survey of India; the Governor of Bengal in Council; the Koninklijke Akademie van Wetenschappen te Amsterdam; the Académie Royale, Brussels; the Bataviaasch Genootschap van Kunsten en Wetenschappen, Batavia; the Société Hollandaise des Sciences, Haarlem; the Kongeligt Norsk Videnskabers Selskab, Trondhjem; the Bureau of American Ethnology, and the Smithsonian Institution, Washington; and the United States Coast and Geodetic Survey.

The following Journals have been added to the Society's subscription list as from January 1922:—*The General Electric Review*, *the Journal of Comparative Psychology*, *The Physical Review*, *The Kolloid Zeitschrift* and *Kolloid-chemische Beihefte*. The *Zeitschrift für physikalische Chemie* has been completed up to and including Band 96 (1920).

The purchases included volume 17 of *The Royal Society's Catalogue of Scientific Papers*, 1884—1900; and a copy of the *World List of Scientific Periodicals* has been ordered.

The Library continues to be satisfactorily used for reference purposes; and, during the year, 304 volumes have been borrowed. The number of books borrowed during the previous year was 357, and during 1919-20, 434.

The publication of the Society's *Memoirs and Proceedings* has been continued under the supervision of the Publications Committee. During the year volume 64 (1919-20), Part II (end), and volume 65 (1920-21), Part I, of the *Memoirs and Proceedings*, have been published. The concluding part (II) of volume 65, with a revised list of members, and Volume 66 (1921-22) are in the printer's hand.

The exchange of bound volumes for the corresponding

unbound parts of the *Memoirs and Proceedings* has been discontinued.

The librarians have been added to the Publications Committee for the consideration of library matters.

#### *Donations.*

The Society has received the following donations, in addition to those recorded in the previous paragraph :—

Mrs. S. J. Hickson and Mrs. L. H. Fletcher : A marriage certificate witnessed by Joseph Dalton, probably the father of John Dalton; another marriage certificate witnessed by John Dalton; and a copy of "The Schoolmaster's Assistant, being a Compendium of Arithmetic," which contains John Dalton's signature inscribed when he was nine years old.

The President, Mr. T. A. Coward : A painting, on metal, representing a dray which belonged to Benjamin Joule, the father of James Prescott Joule.

Professor W. W. Haldane Gee : Copies of the photograph taken during the "Young People's" Meeting in January 1921.

#### *Chemical Section.*

At the Annual General Meeting of the Section the following Officers were elected :—Chairman, Mr. L. E. Vlies; Vice-Chairman, Mr. J. H. Lester; Secretary, Mr. David Cardwell. On account of ill-health, Mr. Vlies resigned the Chairmanship, and Dr. H. F. Coward was elected Chairman for the Session. The Section had a membership of 172 during the year. The following subjects were discussed at meetings held during the year :—" *Researches on Alcohol as a Motor Fuel*," " *The Canadian Meeting of The Society of Chemical Industry*," " *The Sludging of Hydrocarbon Oils*," " *The Development and Design of the Domestic Grate*," " *The Performance of a Centrifuge*," " *The Electrical and Magnetic Properties of Steel* " and " *Briquetting of Coal and other substances.*"

Arrangements have been made whereby the Institution of Civil Engineers (Manchester Association) have held their meetings in the Society's rooms during the year. The Institute of Chemistry (Manchester Section) have also held a Social Evening in our rooms. The following Societies now hold their meetings regularly at 36, George Street :—The Manchester Astronomical Society, The Institution of Civil Engineers (Manchester Association), The Manchester Microscopical Society, The Manchester Statistical Society, and The Society of Dyers and Colourists (Manchester Section).



*Society's House.*

The fire and other insurances on the Society's house have been increased to a total of £20,000, and the new premises have been insured for £500.

Permission has been granted to the Wellcome Historical Research Museum to have replicas made, for that Museum, of seven pieces of John Dalton's apparatus in the Society's possession.

Six new Dalton Medals, in bronze, have been struck.

The house is now open from 9.0 a.m. to 10.0 p.m. every week-day except Saturday, on which day the hours are from 9.0 a.m. to 2.0 p.m.

*Building Extension and Alterations.*

Since the purchase of the requisite plot of land the scheme of building extension and alterations, with the exception of minor interior adjustments, has remained in abeyance awaiting more favourable circumstances. A sum of £1,378 has been subscribed or promised by 113 members, and, in addition, rents received from the tenants of the premises have been added to the fund.

## COMMITTEES.

The Committees appointed by the Council during the year were as follows :—

*House and Finance.*

The President, Mr. R. L. Taylor, Mr. W. H. Todd, Mr. R. H. Clayton, Mr. C. L. Barnes, Dr. Wilfrid Robinson, Mr. L. E. Vlies, Mr. Francis Jones, Dr. H. F. Coward and Professor T. H. Pear.

*Wilde Endowment.*

The President, Mr. R. H. Clayton, Mr. Francis Jones, Dr. H. F. Coward and Professor T. H. Pear.

*Publications.*

The President, Professor F. E. Weiss, Dr. F. W. Atack, Professor Sydney Chapman, Professor W. W. Haldane Gee, Professor T. H. Pear, Mr. C. L. Barnes and Dr. Wilfrid Robinson (Library matters) and the Assistant Secretary.

*Library and Apparatus.*

The President, Mr. C. L. Barnes, Professor W. W. Haldane Gee, Dr. Wilfrid Robinson and the Assistant Secretary.

*NOTE.—The Treasurer's Accounts of the Session  
1921-1922 have been endorsed as follows :*

April 6th, 1922. Audited and found correct.

We have also seen, at this date, the Certificates of the following Stocks held in the name of the Society :—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294 and 12,323; £7,500 Gas Light and Coke Company Ordinary Stock (No. 8/1960); £100 East India Railway Company 4% Annuity Stock (No. 4032); and the deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declarations of Trust.

Leases and Conveyances dated as follows :—

22nd	Sept.,	1797
23rd	Sept.,	1797.
25th	Dec.,	1799.
25th	Dec.,	1799.
23rd	Dec.,	1820.
23rd	Dec.,	1820.

Declarations of Trust :—

24th	June,	1801.
23rd	Dec.,	1820.
8th	Jan.,	1878.

Appointment of New Trustees :—

30th April, 1851.

We have also seen at this date Conveyance dated 7th December, 1920, relating to the recently acquired property at 21, Back George Street, Manchester.

We have also seen Bankers' acknowledgment of the investment of £300 in the 5% War Loan :—2 Bonds for £100 each, Nos. 71827 and 366270; and 2 Bonds for £50, Nos. 131577 and 31358.

We have also verified the balances of the various accounts with the bankers' pass books.

(Signed) { JOHN K. WOOD.  
              { R. G. FARGHER.

## MANCHESTER LITERARY

Dr.

*R. H. Clayton, Treasurer, in Account with the*

	£	s.	d.	£	s.	d.
To Balance, 1st April, 1921 ... ..				24	4	4
To Members' Subscriptions :—						
Half Subscriptions, 1920-21, 3 at £1 1s. 0d.	3	3	0			
" 1921-22, 18 " " "	18	18	0			
" " 1 " £1 1s. 3d.	1	1	3			
" " (½yr.) 3 " 10s. 6d.	1	11	6			
" 1922-23, 2 " £1 1s. 0d.	2	2	0			
Subscriptions :— 1918-19, 1 at £2 2s. 0d.	2	2	0			
" 1919-20, 5 " "	10	10	0			
" 1920-21, 30 " "	63	0	0			
" 1921-22, 250 " "	525	0	0			
" 1922-23, 2 " "	4	4	0			
				631	11	9
To Student Associates :—						
Subscriptions, 1921-22, 10 at 10s. 6d. ... ..				5	5	0
To Sale of Publications :—						
Memoirs and Proceedings ... ..	22	6	11			
Catalogues ... ..	0	7	0			
				22	13	11
To Sir Dugald Clerk, 1,000 copies of Joule Memorial Lecture	10	4	0			
To Manchester Museum, 450 Memoirs, Vol. 65, No. 1 ...	3	9	0			
To Prof. Miles Walker, printing of Memoir, Vol. 65, No. 6 ...	22	6	11			
To Sale of Duplicate Volumes ... ..	28	6	10			
To Transfers from Wilde Endowment Fund ... ..	82	0	6			
To Dividends :—						
Natural History Fund ... ..	42	17	6			
Joule Memorial Fund ... ..	13	0	10			
Wilde Endowment Fund ... ..	1	15	0			
				57	13	4
To Bank Interest ... ..				0	19	5
To Expenses of Meetings :—						
Institution of Civil Engineers (Manchester Association) ... ..	10	0	0			
Manchester Astronomical Society ... ..	9	0	0			
" Microscopical Society ... ..	15	0	0			
" Statistical Society ... ..	5	0	0			
Society of Dyers and Colourists (Manchester Section) ... ..	2	0	0			
				41	0	0
To Refunded Income Tax :—						
1918-19 ... ..	96	17	10			
1919-20 ... ..	92	8	9			
1920-21 ... ..	110	16	6			
				300	3	1
To National Health Insurance Act deductions ... ..				2	9	5
To Unemployed Act deductions ... ..				3	4	8
To overdraft * at Williams Deacon's Bank, April 1st, 1922 ...	87	17	4			
				£1323	9	6

\* This Fund is also debtor to the Wilde Endowment Fund to the extent of £381. 19s. 0d.; to the Joule Memorial Fund, £141 11s. 2d., and to the National History Fund £236 16s. 1d. Total, £760 6s. 3d.

## AND PHILOSOPHICAL SOCIETY.

*Society, from 1st April, 1921, to 31st March, 1922.*

Cr.

	£	s.	d.	£	s.	d.
By Charges on Property :—						
Chief Rent ... ..	9	0	10			
Income Tax and Inhabited House Duty ...	3	17	4			
Insurance against Fire ... ..	29	2	6			
	<hr/>			42	0	8
By House Expenditure :—						
Coal, Gas, Electric Light, Water, etc. ...	75	1	6			
Tea, Coffee, etc., at Meetings ... ..	33	12	2½			
Cleaning, Washing, etc. ... ..	11	0	9			
Replacements ... ..	6	15	5			
Repairs, etc. ... ..	3	2	7			
	<hr/>			129	12	5½
By Administrative Charges :—						
Assistant Secretary's Salary ... ..	150	0	0			
Caretaker and Housekeeper ... ..	132	10	0			
Servant ... ..	26	10	0			
Extra Attendance at Meetings ... ..	10	3	0			
"    "    Weekly ... ..	13	12	0			
Special Meetings' Expenses ... ..	1	18	6			
Postages, Carriage of Parcels, "Memoirs" ...	62	6	3½			
Stationery, Cheques, Receipts, Engrossing, etc.	20	17	9			
Insurance against Liability ... ..	1	6	2			
National Health Insurance Stamps ... ..	5	5	8			
Unemployment "    " ... ..	6	17	7½			
Miscellaneous Expenses ... ..	3	7	2½			
	<hr/>			434	14	2½
By Publishing :—						
Printing "Memoirs and Proceedings," and Illustrations,						
Circulars, etc. ... ..				326	16	2
By Library :—						
Periodicals (except those charged to Natural History Fund)	39	13	2			
By Post Office Telephone ... ..		5	17 9			
By Dalton Medals ... ..		4	10 0			
By Typewriter ... ..		10	10 0			
By Bank Interest on Overdraft ... ..		0	12 7			
By Natural History Fund :—						
(Items shown in Balance Sheet of this Fund) ...		43	1 5			
By Joule Memorial Fund :—						
(Item shown in Balance Sheet of this Fund) ...		10	5 0			
By Wilde Endowment Fund :—						
Dividend Refunded (War Loan) ... ..	1	15	0			
Refunded Income Tax ... ..	228	0	0			
	<hr/>			229	15	0
By Building Fund, Balance paid to Fund ... ..		36	1 1			
By Balance in Treasurer's Hands 1st April, 1922 ...		10	0 0			

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£1323 9 6

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Dr.	JOULE MEMORIAL FUND, 1921-1922.		(Included in the General Account, above.)		Cr.
	£	s. d.		£ s. d.	
To Balance, due to this Fund from the General Fund, 1st April, 1921	121	14 9	By Printing of Joule Memorial Lecture	20 9 0	
To Dividends:—			Less 1,000 Reprints...	10 4 0	10 5 0
Dividend on £100 East India Railway Company's 4% Annuity Stock	4	5 10	By Balance, due to this Fund from the General Fund, 1st April, 1922	141 11 2	
Interest on £250 5% War Loan Stock	8	15 0			
	13	0 10			£151 16 2
To Refunded Income Tax, 1918-19	5	15 4			
1919-20	5	16 3			
1920-21	5	9 0			
	17	0 7			
	£151	16 2			
NATURAL HISTORY FUND, 1921-22		(Included in the General Account, above.)			
	£	s. d.		£ s. d.	
To Balance, due to this Fund from the General Fund, 1st April, 1921	181	17 6	By Natural History Periodicals	27 19 8	
To Dividends on £1,225 Great Western Railway Company's Stock	42	17 6	By Subscriptions:—		
	18 7 6		Entomological Society, 1921 and 1922	4 4 0	
To Refunded Income Tax, 1918-19	18 7 6		Lancashire & Cheshire Fauna Committee, 1921	1 1 0	
1919-20	18 7 6		Palaeontographical Society, 1919	1 1 0	
1920-21	18 7 6		Ray Society, 1921 and 1922	2 2 0	
	55 2 6				8 8 0
	£279 17 6		By Illustrations, Natural History Memoirs	5 7 6	
			By Binding Natural History Periodicals	1 6 3	
			To Balance, due to this Fund from the General Fund, 1st April, 1922	236 16 1	
				£279 17 6	
WILDE ENDOWMENT FUND, 1921-22.					
	£	s. d.		£ s. d.	
To Balance, due to this Fund from the General Fund, 1st April, 1921	381	19 0	By Overdraft at Williams Deacon's Bank, 1st April, 1921	117 15 11	
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	245	0 0	By Assistant Secretary's Salary	150 0 0	
To Interest on £50 5% War Loan Stock	1	15 0	By Maintenance of Society's Library:—		
To Refunded Income Tax, 1918-19	72	15 0	Binding Books	24 18 9	
1919-20	68	5 0	By Transfer to Society's Funds	82 0 6	
1920-21	87	0 0	By Bank Interest on Overdraft	1 17 10	
	228 0 0		By Cheque Book	0 4 2	
To Bank Interest	1 2 3		By Balance, due to this Fund from the General Fund, 1st April, 1922	381 19 0	
			By Balance at Williams Deacon's Bank, 1st April, 1922	99 0 1	
				£857 16 3	



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